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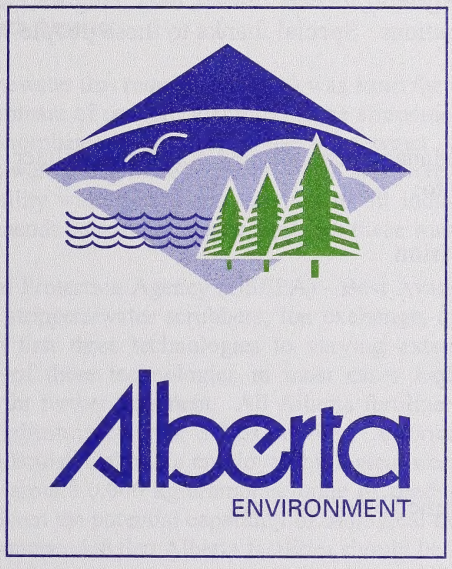
WASTEWATER MANAGEMENT REVIEW FOR THE FERTILIZER MANUFACTURING SECTOR



June 1999

Environmental Sciences Division
Environmental Service

Pub. No: T/458
ISBN: 0-7785-0637-1

This report was prepared by Prasad Valupadas. We would like to acknowledge the assistance of Jeremy Krislock and Brian Yaremko in the compilation of the information contained in the report. We would also like to acknowledge input received from Sandra McDougall, Jay Nagendran, David Spink, Chow-Seng Liu, Robert Stone and George Murphy. Industry co-operation in providing site tours and reviewing the contents of draft reports is greatly appreciated. We would like to specifically recognize David Minckler (Agrium), Chris Micek (Agrium), Mike Fedunec (Agrium), Kent Brandt, Art Hughes, and John Hennig (Sherritt International) for their contributions. Special thanks to those people who took the time to fill out the survey questionnaire.

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EXECUTIVE SUMMARY

This report reviewed the four Alberta fertilizer-manufacturing facilities that continuously discharge wastewater to the environment. The primary purpose of the review was to compare Alberta wastewater production and management practices with practices by similar facilities in other jurisdictions to determine technology based wastewater discharge limits for the fertilizer manufacturing sector. Information on other jurisdiction facilities was obtained by means of a survey (see Appendix C).

The review contains comparisons of wastewater management practices and government regulations of Alberta facilities and other jurisdiction facilities. Wastewater control technologies were reviewed to determine the most feasible technologies for the fertilizer-manufacturing sector. Generally, most government discharge limitations were closely related to the level of technology used in that jurisdiction. A review of the facility surveys received from around the world showed the best environmentally performing facilities were in North America.

The main source of process wastewater that required disposal was from the ammonia and urea processing operations, with the main contaminant of concern identified to be ammonia. All other types of fertilizer manufacturing processes (eg. phosphate) re-cycle or re-use wastewater. Utility wastewaters such as cooling tower/boiler blowdowns were found to be relatively clean and were not reviewed in any detail. It was recommended that since utility wastewaters are common to all industry sectors, a separate study should be conducted that recommends consistent release limits for these wastewaters.

The United States Environmental Protection Agency (USEPA) - Best Available Technology for nitrogen control was found to be steam strippers/water scrubbers, ion exchange, and biological treatment. All Alberta facilities employed the first three technologies to varying extents. The quality of effluent generated showed that the use of these technologies in most cases had been optimized. Alternate technology would be necessary for further treatment. All Alberta fertilizer plants have retention ponds, but their use is limited to pH adjustment and/or solids settling. Information from other jurisdiction facilities revealed one facility in British Columbia employed biological treatment. The facility is able to achieve ammonia release levels around 0.006 kg ammonia/tonne of product, which is well below their regulatory limit of 0.027 kg/t. Given the potential capability of biological treatment and the advancement of treatment technology, it is recommended that Alberta facilities should be required to investigate further treatment of ammonia contaminated wastewater.

The regulatory limit for the USEPA Best Available Technology (BAT) is 0.025 kg ammonia/tonne of product. Current Alberta regulations vary from one facility to another (0.05 - 0.29 kg/t). Most United States facilities are regulated at the 0.025 kg/t level. The following discharge limits for ammonia are recommended for the nitrogen fertilizer manufacturing sector:

- **0.025 kg/t by the year 2005**
- **0.010 kg/t by the year 2010**

The limits should provide a level playing field for Alberta facilities and will ensure Alberta requirements for the fertilizer manufacturing sector are comparable to the best in the world.

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1.0 INTRODUCTION

1.1 Background

Currently in Alberta there are four fertilizer manufacturing facilities that continuously produce wastewater effluent that is released to the environment (excluding irrigation). The wastewater effluent discharge limits vary for each facility, which has raised the issue of what should be the appropriate discharge limits for the industry sector. To address the issue, the four facilities were compared in detail with one another and with fertilizer facilities from other jurisdictions around the world to get a global perspective.

This report reviews the four fertilizer plants with the primary objective of comparing Alberta wastewater management practices with management practices in other jurisdictions to determine technology based wastewater discharge limits. The review will attempt to identify the best pollution control technologies for wastewater management and protection of the environment for the fertilizer manufacturing sector. The recommendations in this report should aid regulators in the review of Alberta fertilizer manufacturing facilities.

1.2 General Approach

The four fertilizer manufacturing plants in Alberta that continuously generate wastewater (Sherritt International – Fort Saskatchewan, Agrium - Redwater and Fort Saskatchewan., Canadian Fertilizers Limited – Medicine Hat) were examined in detail in terms of processes, technology, quality and quantity of wastewaters generated, and current regulated discharge limits. This enabled a general assessment of the current state of Alberta's fertilizer manufacturing facilities, and also allowed direct comparison of Alberta facilities with one another and with other jurisdiction facilities. The primary source of information for Alberta facilities was from approval applications, monitoring reports, site visits, and conversations with plant operators.

To obtain information on other jurisdiction fertilizer facilities in Canada and around the world, a survey was prepared (see Appendix C) and sent to roughly 50 fertilizer manufacturing facilities. The survey was specific to wastewater management and government discharge limits. About 25 surveys were received of which only 10 were used as a basis of comparison. The 10 surveys were screened out based on the amount of information provided, local government regulations, and type of facility (i.e. ammonia and urea processing). The 10 surveys are summarized in Appendix B. Due to requests for confidentiality, the name of each facility has not been included.

The USEPA effluent limitations with respect to the fertilizer-manufacturing sector were also assessed. A global review was necessary in order to compare Alberta facility performance relative to facilities around the world, thereby ensuring that any technology derived limits would be on par with the best in the world.

2.0 FERTILIZER MANUFACTURING

2.1 Chemical Fertilizers - Subcategories

The fertilizer industry is similar to the chemical industry with the major difference being that the chemicals used in the fertilizer sector are primarily nitrogen, phosphorus, and potassium in various combinations. Nitrogen and hydrogen are required for the production of nitrogen fertilizers, phosphate rock is required for the production of phosphate fertilizers, and potassium containing ores are required for the production of potash fertilizers. Alberta does not currently have any facilities that produce potash fertilizers and there is no evaluation in this report on the potash sector.

Most commercial nitrogen fertilizer production use ammonia as a source of nitrogen. The ammonia is typically reacted with other reagents to produce various nitrogen fertilizers or is put directly into solution for use as liquid fertilizer. The other major raw material is hydrogen, which is obtained either from water or hydrocarbons. In Western Canada, due to its abundance, natural gas is the main source of hydrogen. In Canada, about 80-85% of fertilizer production is nitrogen based.

Natural phosphate containing rocks are the main source of phosphate fertilizers. Canada must import phosphate ore from the United States and Africa, and with the high cost of importing the material, there is less than 5% of phosphate fertilizer production in Canada.

Other raw materials required for fertilizer production include sulphuric acid, nitric acid, and phosphoric acid. These chemicals are usually manufactured on-site. As they are critical components for the production of specific fertilizers, it is standard practice to classify the chemicals along with the actual fertilizers within the various subcategories of the fertilizer manufacturing industry.

A fertilizer manufacturing facility may be a single-process plant, which produces a single product, or it may have several process trains, synthesizing several different products simultaneously. The fertilizer manufacturing industry may be described as all those facilities involved in the manufacture of the following:

Nitrogen fertilizers (N)	Urea Nitric acid Ammonia (liquid and aqueous) Ammonium nitrate Ammonium sulphate
Phosphate fertilizers (P)	Phosphoric acid Ammonium phosphate Single superphosphate Triple superphosphate Sulphuric acid
Potassium (Potash) fertilizers	Potassium chloride Potassium sulphate Potassium nitrate Potassium-magnesium sulphate (langbeinite)

2.2 Wastewater Generation

Fertilizer production requires water for the following purposes:

- as cooling water,
- in the generation of steam,
- as a diluent to dilute product or reactants to an acceptable level,
- as scrubber water to clean process streams, and
- as a reactant in the synthesis of products

Wastewater generated at a large-scale fertilizer manufacturing facility maybe recycled, re-used, or collected for treatment and release to the environment. In order to understand the wastewaters generated from fertilizer manufacturing, it is important to study the various plant operations. The amount and quality of a wastewater will vary depending on:

- the type and quantity of product being synthesized,
- the process employed,
- the age and efficiency of the plant,
- the quality of raw materials,
- the level of wastewater treatment employed,
- government wastewater regulations,
- the degree of recycling within the plant, and
- the quality of raw water.

Mechanistically, every fertilizer manufacturing facility performs the same function: the chemical recombination of basic raw materials into new, agriculturally useful chemical entities. For nearly every large-scale fertilizer manufacturing facility in operation worldwide (including Canada), a limited set of basic, well known chemical reactions are employed. In general, for any fertilizer plants producing the same product, the same wastewaters are generated, and therefore the resulting management issues are the same.

Where such plants differ is in the area of wastewater minimizing practices, whereby process variations and control technologies are applied in an effort to increase productivity and decrease the generation of wastewater. It is important for the environmental regulator to understand the source of wastewaters at a given facility, and how they may be controlled to mitigate there impact on the environment.

A cursory review of the nitrogen and phosphate fertilizer sub-categories revealed that only the nitrogen categories produce any process wastewater. Process wastewater only includes wastewaters generated from actual process operations. Table 1.0 shows what each Alberta Facility manufactures and whether there is a process wastewater that is generated for eventual release to the environment.

TABLE 1.0 – Alberta Fertilizer Facility Process Wastewater Sources

Sherritt International – Fort Sask.	
- Anhydrous ammonia	Process wastewater discharge
- Solid urea	No process wastewater discharge
- Sulphuric acid	No process wastewater discharge
- Ammonium Sulphate	Process wastewater stored in ponds
Agrium – Fort Sask.	
- Anhydrous ammonia	No wastewater discharge
- Solid urea	No wastewater discharge
	Note: Ammonia contaminated wastewater released to Sherritt International is from utility wastewaters and surface runoff.
Agrium – Redwater	
- Anhydrous ammonia	Process wastewater is sent to deepwell
- Solid urea	Process wastewater is sent to deepwell
- Urea ammonium nitrate	No process wastewater discharge
- Nitric acid	No process wastewater discharge
- Ammonium nitrate	Process wastewater is sent to deepwell
- Sulphuric acid	No process wastewater discharge
- Phosphoric acid	No process wastewater discharge
- Mono ammonium phosphate	No process wastewater discharge
	Note: Ammonia contaminated wastewater released to the environment is from utility wastewaters and surface runoff.
CFL – Medicine Hat	
- Anhydrous ammonia	Process wastewater discharge
- Solid urea	Process wastewater discharge

It is important to note that, for this report, process wastewater does not include utility wastewaters such as cooling tower blowdown and boiler blowdown. These sources will be discussed separately. Table 1.0 shows that the only sources of process wastewater within the nitrogen category are from the anhydrous ammonia production (ammonia plant) and the urea production plants, therefore, only these two processes are reviewed in this report.

3.0 NITROGEN FERTILIZER PLANTS

3.1 General

Nitrogen fertilizers and nitrogen fertilizer precursors include ammonia, nitric acid, ammonium nitrate, urea, ammonium sulphate, and a number of minor products. Originally, all nitrogen fertilizers were derived from natural, organic materials. Today, fixed atmospheric nitrogen as ammonia is by far the most important source of fertilizer nitrogen in existence. This nitrogen is applied in a number of forms ranging from anhydrous ammonia to solid urea to Nitrogen/Phosphate/Potassium blends. The synthetic pathways leading to the production of ammonia and urea is discussed below.

3.2 Ammonia Plants

The fundamental purpose of an ammonia plant is to facilitate the elementary reaction of hydrogen and nitrogen to form ammonia

$$N_2 + 3H_2 \Leftrightarrow 2NH_3 \qquad (1)$$

In general, nitrogen is obtained directly from the atmosphere. Hydrogen is available in pure form or synthesized from the breakdown of hydrocarbons. If not available in pure form, upstream processes are necessary to ensure a steady supply of nitrogen and hydrogen for the ammonia synthesis process.

There are two types of ammonia production processes currently in use, the partial oxidation process and the steam reforming process. The primary difference between these two lies in the manner in which hydrogen is produced from a hydrocarbon precursor. Partial oxidation achieves the gasification of heavy hydrocarbon feeds such as residual oils and coal by reacting them directly with oxygen in a non-catalytic reaction, yielding hydrogen and carbon monoxide. In steam reforming, water reacts in the presence of a catalyst with light hydrocarbons such as natural gas, naphtha and LPG to yield gaseous hydrogen and CO_2. In each process, nitrogen is obtained directly from the atmosphere.

In practice, steam reforming generates more hydrogen than does partial oxidation, it produces less byproduct CO_2, it is a simpler process overall, and it is the most economical means of producing synthesis gas hydrogen. Consequently, steam reforming of natural gas is currently the dominant technology employed in the world today for the synthesis of ammonia, and is the process used by Alberta fertilizer plants, therefore the partial oxidation process will not be discussed.

Catalytic steam reforming of natural gas can be subdivided into seven basic steps:

1. Feedstock desulphurization

Natural gas typically contains significant levels of sulphur and sulphur compounds. Sulphur must be removed as it can poison the reforming catalysts in downstream steps of the process. To remove the sulphur, the natural gas is heated to a temperature of 300°C to 400°C in the presence of hydrogen (usually recycled from the synthesis section), thereby hydrogenating the sulphur compounds to H_2S, which is then adsorbed onto pelletized oxide for later disposal:

$$R\text{-}SH + H_2 \Leftrightarrow H_2S + R\text{-}H \qquad (2)$$
$$H_2S + ZnO \Leftrightarrow ZnS + H_2O \qquad (3)$$

2. Primary Reformation

The desulphurized natural gas is compressed, mixed with excess process steam, and then reacted with water in the presence of a nickel or nickel-chromium catalyst. The composition of the outlet stream depends primarily upon the following equilibria:

$$CH_4 + H_2O \Leftrightarrow CO + 3H_2 \qquad (4)$$
$$CO + H_2O \Leftrightarrow CO_2 + H_2 \qquad (5)$$

The first reaction is highly endothermic, and heat is supplied mainly by firing natural gas. Only 50% to 60% of the total generated heat is used in the reaction; the waste heat is released as flue gas to a waste heat boiler to produce steam for use elsewhere. Roughly 65% to 75% of the methane is converted in this step. Upon leaving the primary reformer, the gas is a mixture of CO_2, CO, H_2O, CH_4 and H_2 at a temperature of approximately 800°C to 900°C.

3. Secondary Reformation

Just before entering the secondary reformer, the process gas is mixed with heated air. The reaction in the primary reformer is adjusted so that the effluent air meets both thermodynamic and stoichiometric requirements in the secondary reformer. The further combustion of the nitrogen and the un-reacted hydrocarbons raises the temperature to over 1000°C, allowing the remaining methane to be converted to CO and H_2. The outlet gas from the secondary reformer consists primarily of CO_2, CO, H_2, and N_2 and it is cooled immediately to 350°C and 450°C downstream of the reformer.

4. Shift conversion

After reformation, the shift conversion reaction reduces the CO in the process gas to ppm levels by converting it to CO_2 and H_2:

$$CO + H_2O \Leftrightarrow CO_2 + H_2 \qquad (5)$$

Reducing CO to ppm levels prevents poisoning of the catalysts during the synthesis step. As well, CO_2 is much easier to remove than CO. In this reaction, a high temperature favours reaction velocity, while low temperature favours product formations, so two shift conversion steps are applied in series, a high temperature shift (HTS) and a low temperature shift (LTS). In the HTS, process gas mixes with high-pressure steam and passes over a FeO/Cr catalyst at a temperature of about 400°C. The process gas is then cooled to around 200°C, where remaining CO is shifted to CO_2 over a CuO/ZnO catalyst. The process gas is then condensed to remove excess steam (condensate) before removal of CO_2.

5. Carbon Dioxide Removal

After shift conversion and condensate removal, the process gas contains mostly H_2, N_2, CO_2. The CO_2 (formerly CO) is also detrimental to the synthesis catalysts, so it too must be removed. CO_2 removal is by both chemical and physical processes, where the CO_2 either reacts with or is adsorbed onto a circulating chemical solvent solution. This spent solvent solution is then regenerated via a stripper, from which the CO_2 may be either vented to waste or collected for use elsewhere. Typical chemical solvents are glycol dimethylethers (Selexol), potassium carbonate and others. The regeneration of the solvents (in the stripper) occurs by steam stripping or by flash tanks and thus is an endothermic process.

6. Methanation

Any small amounts of CO and CO_2 still remaining in the synthesis gas are converted to inert methane by catalytic methanation (which is the reverse of the reforming reactions):

$$CO + 3H_2 \Leftrightarrow CH_4 + H_2O \qquad (6)$$
$$CO_2 + 4H_2 \Leftrightarrow CH_4 + 2H_2O \qquad (7)$$

The process stream is then cooled and the product water is removed as condensate.

7. Ammonia Synthesis

Purified synthesis gases are cooled and compressed, then they are passed over an iron catalyst in the ammonia converter. Synthesis typically occurs at 20 MPa to 30 MPa at a temperature of 350°C to 550°C, but it is reversible, such that the amount of ammonia formed depends strongly upon temperature and pressure in the reaction vessel – a matter of primary importance to the plant operator:

$$N_2 + 3H_2 \Leftrightarrow 2NH_3 \qquad (8)$$

Even at optimum temperature and pressure, only 20-30% of the synthesis gas reacts per pass. Formed NH_3 is removed by refrigeration, and unreacted gases are recycled back to the converter. In order to produce sufficiently low temperatures to favour ammonia condensation, pressurized ammonia is itself used as a refrigerant. Product ammonia is sent to atmospheric storage tanks equipped with refrigeration.

3.3 Urea Plants

The following reactions take place to form urea:

$$2NH_3 + CO_2 \Leftrightarrow NH_2CO_2NH_4 \qquad (9)$$

$$\underset{\text{(ammonium carbamate)}}{NH_2CO_2NH_4} \Leftrightarrow \underset{\text{(urea)}}{NH_2CONH_2} + H_2O \qquad (10)$$

Urea is produced by reacting ammonia and carbon dioxide to form ammonium carbamate. The ammonium carbamate then dehydrates to form urea.

1. Solution Formation and Concentration

The formation of urea is dependent on temperature, pressure, and concentrations of ammonia, carbon dioxide, water, urea, and carbamate. It has been shown that yields can be improved by raising the temperature and pressure and by changing the molar ratio. Excess water affects equilibrium yield by reducing the unit's productive capacity and increasing the quantity of water to be evaporated, thus consuming more energy. Urea can be produced by once through processes, partial recycle processes, and total recycle processes.

2. Crystallization and Evaporation

Irrespective of the solution formation process, the two methods of concentrating urea solution prior to solid formation are crystallization and evaporation. The method chosen depends on the acceptable biuret ($NH_2CONHCONH_2$) level, an impurity formed by a side reaction. To obtain urea with less than 0.4% biuret, crystallization is necessary. A vacuum crystallizer evaporates water. The urea crystal slurry is then centrifuged, solids separated, washed and dried. These solids can now be screened and coated as a final product or melted and sent through a solidification process.

3. Solidification

In the prilling process, concentrated urea solution is pumped to the top of a tower and forced through a spraying device. The urea droplets fall countercurrent to an airflow. The airflow cools the falling droplets and allows the droplets to crystallize before reaching the bottom of the tower, where they are removed.

In the granulation process, the urea melt enters a granulation drum through a spray bar, which distributes the melt on a tumbling bed of particles. Particles of appropriate size exit the drum by passing over a retaining dam. In the pan granulator, the circular pan rotates and is tilted. Feed material deposited at the top falls through a fine spray of liquid urea and the larger granules spill over the edge of the tilted pan onto a conveyor belt and into a rotary cooler.

4. Product Finishing and Handling

The final preparation consists of cooling, screening, and coating. Oversized and undersized material is recycled. Very little of the solid urea produced is coated because the practice of injecting formaldehyde or phosphate-based additives into the melt prior to solid formation has increased.

4.0 WASTEWATER SOURCES AND CHARACTERISTICS

This section will primarily focus on the wastewaters generated from the Ammonia and Urea processes as these are the only sources of process wastewater that are discharged to the environment. The wastewaters produced from these processes originate from:

- Process condensate
- Closed-loop cooling tower blowdown
- Closed-loop boiler blowdown

Tables 2.0 and 3.0 outline the sources of process wastewaters in an ammonia plant and urea plant respectively, and how they are managed by the four Alberta facilities. The main contaminants in process wastewater from nitrogen plants are ammonia, nitrate-nitrogen, and organic-nitrogen. Table 4.0 shows the typical average concentration of contaminants in the wastewater of the four Alberta facilities. The primary source of nitrogen in the wastewater is from the process wastewater streams. Other sources of nitrogen may be from contaminated surface runoff and utility wastewaters. The phosphate and the suspended solids would primarily be from the cooling tower/boiler blowdowns. The phosphate and suspended solids levels are well within the objectives indicated and show that the utility wastewaters are not a concern. Surface runoff that is combined with plant wastewater prior to discharge may also contribute to the contaminant levels.

The main source of ammonia is from the ammonia plant, while organic-nitrogen can be sourced to the urea plant. Nitrate is primarily from the nitrification of ammonia, or from nitrate processes. Ammonia is the primary contaminant of concern. Table 4.0 shows that the current levels of ammonia in the wastewaters are well above the 5 mg/L objective used for surface runoff discharges at Oil and Gas facilities in Alberta. This objective was the only industrial ammonia limit in Alberta available as a basis of comparison. Since the objective is for surface runoff, it may not represent an appropriate treatment target for process wastewater from fertilizer manufacturing.

Total ammonia nitrogen is essentially the combined concentration of the un-ionized (NH_3) and ionized form (NH_4^+). Depending on the pH and temperature, the relative proportion of each form varies with the un-ionized form increasing in proportion with increase in pH and temperature. It is the un-ionized form (NH_3) that is of concern due to its toxicity in the aquatic environment.

A recent review of the fertilizer facilities has resulted in wastewater discharge limitations being set such that ammonia no longer poses a receiving water quality concern. Any further reductions would be based on technology capabilities (technology based limits) as current department policy is to adopt the more stringent of Water Quality vs. Technology limits.

TABLE 2.0 - Ammonia Plant Process Wastewater Management

Company	Process Condensate	Purge Gas Scrubber Liquor
Sherritt International	- reused for contaminated process steam - vented from reformer stack - some process wastewater released to pond system	- scrubbed to recover NH_3; - tail gas burnt in as fuel in Utility boilers
Agrium (Fort Sask.)	- steam stripped and reused as boiler feed; - some discharge to Sherritt ponds	- dilute NH_3 solution used in urea plant - scrubbed to recover ammonia - hydrogen and fuel recovery from tail gas
Agrium (Redwater)	- majority used as boiler water - remainder down deepwell	- scrubbed to recover NH_3; - H_2 cryogenically recovered; - tail gas burnt in primary reformer
Canadian Fertilizers	- majority stripped of NH_3 and used as boiler water; - remainder discharged to effluent ponds; - stripped NH_3 vented from reformer stack	- insufficient information

TABLE 3.0 - Urea Plant Process Wastewater Management

Company	Produced Water	Evaporator Condensate
Sherritt International	- evaporated to reduce volume released to phosphate pond for subsequent evaporation	- NH_3 condensed for reuse; - evaporated to reduce volume and released to phosphate pond
Agrium (Fort Sask.)	- stripped of NH_3; - evaporated to atmosphere	- condensed as aqua (NH_3, H_2O); - steam stripped of NH_3 - water used in granulator scrubber and recycled to evaporator
Agrium (Redwater)	- discharged to retention pond for deepwell disposal	- insufficient information
Canadian Fertilizers	- majority reused as boiler water; - some discharged to equalization basin and then to river	- condensed and purified to recover NH_3 and CO_2 for recycle; - water sent too water treatment for reuse

TABLE 4.0 - Actual Wastewater Emission Levels for Alberta Fertilizer Plants

Parameter	Sherritt / Agrium combined (Jan/92-Jul/97)		Agrium - Fort Sask. (Jan/97-Dec/98)		Agrium - Redwater* (Jan/92-Jul/97)		Canadian Fertilizers (Jan/92-Jul/97)		Objective**
	(kg/d)	(mg/l)	(kg/d)	(mg/l)	(kg/d)	(mg/l)	(kg/d)	(mg/l)	(mg/l)
NH_3-N	369.86	63.2	37.1	16.5	36.42	6.8	80.70	24.1	5.0
Org-N	51.25	8.8+	6.1	2.7	11.73	2.2	21.81	6.5	
NO_3-N	91.65	15.7	41.4	18.4	33.56	6.3			10.0
PO_4	13.15	2.2	6.1	2.7	20.02	3.7	16.62	5.0	3.0
TSS	94.06	16.1	126.0	56.0	64.73	12.1	58.37	17.4	25.0
Production (t/d)									
Ammonia	1750		1300		2580		3190		
Urea	1470		1180		1800		2035		
Flow (m^3/d)	5855		2250		5342		3350		

- Effluent from Ammonia and Urea processing are disposed via deepwell injection and do not contribute to the contaminant levels listed in Table 4.0.

** Surface runoff objectives

4.1 Cooling Tower Blowdown and Boiler Blowdown

The largest amount of water is used for cooling processes. The next largest use is for steam generation. The closed-loop nature of cooling and boiler waters results in a build-up of solids. To prevent an excessive build-up of these solids, it is necessary to maintain a purge stream from each closed loop, which is discharged to the wastewater management system. Make-up water is added to maintain a constant volume in the water systems. Treatment chemicals are added to the water systems for pH, scale, slime and corrosion control. Depending on the location of the cooling towers within the plant process area, there may be some deposition of contaminants from air emissions into the cooling water system.

The source of contaminants in the utility wastewaters are residual water treatment chemicals and any contaminants deposited into the utility system from air emissions. As the type of treatment chemicals used by each facility is site-specific, it is not possible to compare these waters between facilities. Cooling tower/boiler blowdown are also common wastewaters for many other industrial sectors that require cooling water and steam for their processes. Due to the site-specific nature of the treatment chemicals, the clean nature of the wastewaters, and the fact that these streams are common to many other industrial sectors, cooling tower/boiler blowdown will not be discussed further. However, it is proposed that these waters be reviewed on an industry wide basis and a guideline be developed for the best management of these wastewaters.

4.2 Process Condensate

In the catalytic steam reforming of natural gas in an ammonia plant, shift gases pass to the low temperature shift converter and are cooled to approximately 55°C. Un-reacted steam is condensed and separated from the gas in a knockout drum. This condensed steam is the source of more than 90% of the process wastewater. Additional condensate is removed from the cooled gas that leaves the methanator. Other process wastewater includes purge gas scrubber water, which is formed from the treatment of purge gas. Sources of process wastewater from the urea plant are from the evaporator condensate, scrubber bottoms and produced water (excess water from the process).

4.3 Nitrogen Air Emissions

Before the levels of nitrogen in wastewater can be compared between Alberta facilities, it is important to understand what levels of nitrogen are emitted through air emissions. Table 5.0 shows a comparison of the relative ammonia released by each Alberta facility to the atmosphere.

Sherritt International, Agrium–Redwater and Agrium Fort Saskatchewan have the lowest air releases from the ammonia plant. Agrium-Redwater employs a scrubber to remove ammonia from flue gas. The ammonia concentrated water is deepwell injected. Agrium Fort Saskatchewan employs a high-pressure condensate stripper to remove ammonia and other impurities from process wastewater. The high-pressure condensate stripper enables

the recycling of the steam and stripped components back to process and effectively eliminates the release of ammonia and other pollutants through the flue gas. The stripped condensate is sent for use as boiler feed water. Sherritt uses a scrubber to remove ammonia from the purge gas. Scrubber bottoms are recycled back to the Leach plant process. Ammonia emissions to air that originate from Ammonia production will be a maximum of 2.3% of the total ammonia emissions from the Leach plant.

For the urea plants, all plants have similar emissions except Sherritt, which has about double the emission (per tonne of production) compared to the other plants.

TABLE 5.0 – Comparison of NH_3 Emissions to Air from Alberta Fertilizer Plants

	Production	Actual NH_3 Emission		Facility Emission Limit		European BAT
	(t/d)	(kg/hr)	(kg/t)	(kg/hr)	(kg/t)	(kg/t)
Sherritt International						
Ammonia I	450	0.77	0.04	34.3	1.83	--
Urea I	290	42.7	3.53	74.5	6.17	2.05 - 2.58
Agrium - Fort Saskatchewan						
Ammonia*	1300	0.50	0.01	10.0	0.18	--
Urea	1180	48.58	0.99	145.0	2.95	2.05 - 2.58
Agrium - Redwater						
Ammonia I	690	--	--	--	--	--
Ammonia II	1890	0.44	0.01	--	--	--
Urea	1800	119.19	1.59	192.4	2.57	2.05 - 2.58
Canadian Fertilizers Limited						
Ammonia I	1595	68.00	1.02	79.0	1.19	--
Ammonia II	1595	48.69	0.73	79.0	1.19	--
Urea	2035	143.62	1.69	220.0	2.59	2.05 - 2.58

Note: Actual emission data was obtained from stack surveys as shown in Appendix A-4.

* Performance since July 1997 (Recycling of steam-stripped pollutants back to process).

5.0 NITROGEN EMISSION CONTROL

Alberta facilities currently employ steam strippers and water scrubbers as a means of recovering ammonia for recycle and controlling nitrogen that is released to the air and water environments. Any wastewater generated from these processes is sent to retention ponds for pH adjustment and/or settling of solids, with subsequent discharge to the environment. Agrium Redwater, however, deepwells most of its nitrogen contaminated wastewaters. Appendix A details the wastewater management and control technologies employed by each Alberta facility.

The United States Environmental Protection Agency (USEPA) bases its wastewater limitations for the nitrogen fertilizer-manufacturing sector on the following categories:

1. Best Available Technology (BAT) – this technology is the highest degree of control technology that has been achieved or has been demonstrated to be capable of being designed for plant scale operation up to and including no discharge of pollutants.

   BAT for nitrogen control include the following technologies (1974):

   - **Steam stripping or water scrubbing**
   - **Biological treatment (nitrification-denitrification)**
   - **Ion exchange**

2. Best Practicable Control Technology (BPCT) – this level of technology is based upon state-of-the-art unit operations commonly employed in the chemical industry.

   BPCT for nitrogen control includes (1974):

   - **Steam stripping or water scrubbing**

3. Best Available Technology as determined by the European Fertilizer Manufacturer's Association (1995) includes:

   - **Steam stripping and water scrubbing**
   - **Ion exchange**

Ion exchange is the process that treats steam stripped process condensate prior to its recycling for use as boiler feedwater.

Steam stripping is essentially nitrogen removal by steam, which is then released into the air environment. Water scrubbing is the removal of nitrogen in gaseous streams with water for subsequent treatment and release. These technologies are usually good for inlet ammonia concentrations between 100-1300 mg/L. Assuming a 95% efficiency, one can expect exit ammonia concentrations in the range of 20-30 mg/L. Currently, Alberta ammonia and urea plants discharge wastewater to receiving water at concentrations in the

range of 17 to 63 mg/L as shown in Table 4, suggesting that the use of stripper/scrubber technology has been optimized.

For the Urea plants, hydrolysis has also been identified by the USEPA as a control technology option. However, it is felt that this is not really an environmental control option since the process essentially transforms urea to ammonia and carbon dioxide, with the ammonia still requiring treatment.

Wastewater irrigation is another option for disposal of nitrogen contaminated wastewater. The major limitation on irrigation is the storage of wastewater for 6 to 8 months over the winter season. Alberta facilities require a reliable disposal system for this wastewater, due to its continuous generation, therefore, this is not considered a viable option.

5.1 Biological Treatment

Biological treatment involves the treatment of nitrogen contaminated waters by activated sludge or aerated lagoon systems to promote nitrification (transform ammonia to nitrate). Depending on the level of nitrate, further biological treatment using anaerobic processes can transform the nitrate to gaseous nitrogen and oxygen (denitrification).

The major limitation to this type of treatment process in Alberta is the cold climate as nitrification is temperature dependent. Optimum temperature for nitrification is between 26-32°C, and ceases when temperature drops below 5°C. However, process wastewaters are generally warm and should mitigate this problem to a certain extent. Other limitations include a source of organic matter to promote biological oxidation, as process wastewater is generally low in organic matter. Neutralizing agents to mitigate increases in acidity from the oxidation process are also necessary. Both requirements should not pose a concern as most plants have neutralizing agents and organic waste (methanol) sources on-site. This technology is capable of treating 20-60 mg/L of ammonia-contaminated wastewater to less than 10 mg/L assuming a 90% treatment efficiency.

Regulators are recommended to review with Alberta fertilizer facilities the feasibility of transforming the existing wastewater ponds into a biological treatment system. Current technology used by Alberta plants is at the USEPA-BPCT level. The current concentration of ammonia in wastewater discharges is still at a level that further treatment is technically possible through biological treatment.

6.0 COMPARISON OF GOVERNMENT REGULATIONS

Table 6.0 outlines ammonia discharge limits under current approval conditions for Alberta facilities and for facilities in other jurisdictions. From the survey information received from other jurisdictions, it was discovered that the best performing facilities were in North America, therefore only those facilities are included in Table 6.0. Surveys received from facilities in Australia, Asia, and Europe all revealed that their discharge limits and actual discharges were well above technological expectations. Detailed information on other jurisdiction facilities can be found in Appendix B. It should be noted that several overseas facilities acknowledged a need to upgrade their pollution control equipment and indicated that plans were in place to do so in the near future

Table 6.0 shows that most U.S. facilities are required to meet an ammonia limit of 0.025 kg/t as a wastewater discharge limit. This is a 30-day monthly average value. The B.C. facility has a similar regulatory limit (0.027 kg/t) to the U.S. facilities, but actual performance data shows discharges around 0.006 kg/t. The low value is a result of biological treatment and may be a good measure of the treatment level that can be achieved by this technology.

By the year 2005, all Alberta facilities will be near the USEPA BAT level; however, they will all be at different levels (0.03, 0.02, 0.01 kg/t). Currently, all Alberta facilities except Sherritt-Fort Saskatchewan are achieving levels between USEPA BAT and BPCT. The higher levels for Sherritt can largely be attributed to surface runoff from the plant processes areas. Sherritt has implemented a program of source control measures to address the concern. Although a site-specific discharge limitation may be necessary for this facility until source control is complete, the 0.03 kg/t (52.5 kg/d) limit for the year 2005 for Sherritt must be maintained as the minimum requirement as it is water quality based.

Agrium-Redwater process wastewater from ammonia and urea processing is recovered (about 2600 kg/d of ammonia) and disposed via deepwell. Alberta Government policy calls for the conservation of water whenever possible. The deepwell disposal of wastewater that can be treated is not generally permitted. As this report has identified alternate treatment and management options for process wastewater, Agrium-Redwater should be required to re-assess current deepwell practices. Agrium-Fort Saskatchewan and Canadian Fertilizers appear to manage their ammonia wastewaters in the best manner and therefore provide a basis for evaluation. Both facilities have comparable wastewater generation per tonne of product and should reflect the amount of process wastewater generated from ammonia and urea processing. The current limits set for Agrium-Redwater and Canadian Fertilizers are site-specific based on the performance of their wastewater management systems.

TABLE 6.0 – Comparison of NH_3 Wastewater Discharges to the Environment

Company	Actual NH_3 Emission Level (kg/t)	NH_3 Emission Limit (kg/t)	Europe BAT (kg/t)	USEPA BAT (kg/t)	USEPA BPCT (kg/t)
Sherritt International					
Sherritt – Agrium combined	0.21	0.290	0.1	0.025	0.0625
(by the year 2000)		0.160			
(by the year 2005)		0.030			
Agrium – Fort Saskatchewan	0.03	--	0.1	0.025	0.0625
Sherritt	0.71	--	0.1	0.025	0.0625
Agrium – Redwater	0.01	0.100	0.1	0.025	0.0625
(by the year 1999)		0.045			
(by the year 2002)		0.020			
Canadian Fertilizers Limited	0.024	0.050	0.1	0.025	0.0625
(by the year 2000)		0.030			
(by the year 2005)		0.010			
Others:					
Pacific Ammonia (B.C.)	0.006	0.027	0.1	0.025	0.0625
Terra Nitrogen (Oklahoma)	0.03	0.050	0.1	0.025	0.0625
Farmland Industries (Nebraska)	0.03	0.050	0.1	0.025	0.0625
Arcadian Fertilizer (Georgia)	N/A	0.025	0.1	0.025	0.0625
Terra Industries (Iowa)	N/A	0.025	0.1	0.025	0.0625
Arcadian Fertilizer (Iowa)	N/A	0.025	0.1	0.025	0.0625

6.1 Evaluation of Standards

Table 7.0 shows the effluent concentrations that would be associated with various ammonia discharge limits. For this review, only the data for Canadian Fertilizers Limited and Agrium-Fort Saskatchewan are considered as they appear to represent the best wastewater management practices for the fertilizer sector in Alberta.

Alberta's policy with respect to establishing effluent limits is to adopt the more stringent of technology-based and water quality-based limits. Current wastewater releases from Alberta fertilizer industries meet water quality based limits but this evaluation indicates that technologies exist to further reduce ammonia releases. For example, at the 0.025 kg/t level (USEPA-BAT), the concentration of ammonia in the wastewater would be around 20 mg/L. Biological treatment methods are available to reduce ammonia levels in wastewater to below 10 mg/L which translates to an ammonia standard of less than 0.01 kg NH_3/t of product. This is therefore considered an appropriate goal for Alberta facilities (e.g. 10 year phase in period), and is in keeping with the continuous environmental improvement principle Alberta Environment applies to all regulated industry. In the interim, the 0.025 kg/t limit of the USEPA appears to be an appropriate regulatory limit/target.

TABLE 7.0 – Effect of Varying NH_3 Standards on NH_3 Emissions to Water from Alberta Ammonia Plants (based on present effluent volumes)

Company	Production (t/d)	Effluent (m^3/d)	NH_3 Standard							
			0.01 kg/t		0.02 kg/t		0.025 kg/t		0.03 kg/t	
			NH_3 Emission Level		NH_3 Emission Level		NH_3 Emission Level		NH_3 Emission Level	
			(kg/d)*	(mg/l)	(kg/d)*	(mg/l)	(kg/d)*	(mg/l)	(kg/d)	(mg/l)
Sherritt – Agrium combined	1750	5855	17.5	3.0	35.0	6.0	43.8	7.5	52.5	9.0
Agrium – Fort Saskatchewan	1300	2250 (1.73 m^3/t)	13.0	5.8	26.0	11.5	32.5	14.4	39.0	17.3
Sherritt International	450	4088 (2.07 m^3/t)	4.5	1.1	9.0	2.2	11.3	2.8	13.5	3.3
Canadian Fertilizers Limited	3190	3350 (1.05 m^3/t)	31.9	9.5	63.8	19.0	79.8	23.8	95.7	28.6

* Mass Loading based on current nominal production

Definitions:

BAT - Best Available Technology

BPCT – Best Practicable Control Technology

European BAT - 0.10 kg/t

USEPA BAT - 0.025 kg/t

USEPA BPCT - 0.0625 kg/t

7.0 SUMMARY AND CONCLUSIONS

1. Cooling tower/boiler blowdowns are generally clean waters with residual treatment chemicals being the major concern. These waters must be reviewed site specific based on treatment chemicals used.

2. For the fertilizer manufacturing sector, process wastewater that is discharged to receiving water is generated primarily from ammonia and urea processing, and is essentially condensate water contaminated with ammonia and/or urea.

3. Except for Sherritt, all other Alberta facilities have wastewater treatment systems with effluent ammonia levels in the range of USEPA regulatory levels.

4. Higher ammonia levels in Sherritt's wastewater is mainly from contaminated surface runoff. A temporary site-specific discharge limit may be required for this facility until source control measures are completed. However, any proposed limit must ensure water quality concerns are also mitigated.

5. Agrium-Redwater's process wastewater from Ammonia and Urea plants is recovered and disposed via deepwell injection.

6. Agrium Fort Saskatchewan and Canadian Fertilizers Limited (CFL) had the lowest ammonia levels in wastewater, with ammonia wastewater discharges in the range of the USEPA-BAT level (0.025 kg ammonia/tonne of product).

7. Agrium Fort Saskatchewan's installation of a high pressure condensate stripper made it feasible to recycle the steam stripped components back to process, and essentially eliminated the release of ammonia and other pollutants through the flue gas.

8. By the fall of 1999, Sherritt International will be directing their effluent to a municipal sewage treatment facility with biological nutrient removal capabilities.

9. The best environmentally operated facilities from the surveys received worldwide were in North America. All U.S. facilities were at or near a Best Available Technology level of 0.025 kg ammonia/tonne of product.

10. A facility in British Columbia appeared to have the best effluent treatment system. The use of biological treatment enables the facility to achieve ammonia discharge levels as low as 0.006 kg/t.

8.0 RECOMMENDATIONS

1. Utility wastewaters such as cooling tower blowdown and boiler blowdown should be reviewed to develop a consistent set of wastewater management standards that can be applied to all industrial sectors.

2. Contaminated surface runoff is the main contributor to higher levels of ammonia in Sherritt's wastewater. The company's current program of source control measures should mitigate this problem. If there are no other ammonia sources, then the limits recommended in this report should also apply to Sherritt's wastewater discharge. These limits will not be required once Sherritt begins disposing of wastewater to the municipal sewage treatment system.

3. Agrium-Redwater's practice of deepwelling nitrogen contaminated wastewater runs against the principle of water conservation and the Department's policy of not allowing the deepwelling of wastewaters that can be treated. The company's rationale for employing deepwell disposal should be reviewed. If adequate justification is not presented, then the company should phase out the practice.

4. Current practices employed by Canadian Fertilizers Limited and Agrium-Fort. Saskatchewan represent BAT currently for Alberta. However, biological treatment will allow for further reduction in ammonia releases. Technology limits are based on the principles of pollution prevention/minimization and anti-degradation, with the ultimate goal of zero contaminant release. Based on these principles, biological treatment should be pursued with Alberta facilities. Sherritt has already initiated this by implementing measures that allow for the release of their wastewater to a municipal sewage treatment facility with biological nutrient removal capability.

5. The following technology based effluent limits for ammonia (NH_3-N) are recommended for Alberta fertilizer facilities:

   0.025 kg/t by the year 2005
   0.010 kg/t by the year 2010

6. A limit of 0.025 kg/t is currently achievable by all facilities except Sherritt. The level is consistent with the best fertilizer facilities in the world. The 5-year phase in period allows Sherritt to review all sources of nitrogen and take appropriate source control measures where necessary.

7. A limit of 0.01 kg/t represents the long-term goal for contaminant reduction. The 10-year time period allows for treatment feasibility studies and technology implementation to achieve this level.

9.0 REFERENCES

1. United States Environmental Protection Agency, Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Basic Fertilizer Chemicals Segment of the Fertilizer Manufacturing Point Source Category, document number PB-238652, March, 1974

2. European Fertilizer Manufacturer's Association (EFMA), Best Available Techniques for Pollution Prevention and Control in the European Fertilizer Industry, Booklet numbers 1 of 8 and 5 of 8. Brussels, 1995.

3. Review of the Canadian Fertilizer Industry and Evaluation of Control Technology. Environment Canada Report EPS 2/AG/1, September 1987.

APPENDIX A

Alberta Fertilizer Plants

Appendix A-1
Alberta Fertilizer Plant Comparison of Wastewater Management

	Pollution Control Equipment	Effluent Treatment System
Sherritt International NH_3 plant	- CO_2 flash drum removes CO_2 from process condensate in NH_3 plant. - Condensate polisher removes iron content of process condensate before it is used as flue gas boiler water.	- runoff and selected process streams collect in two storm ponds (40,000 m^3 each). Pumped to Clarifier where cold lime treatment removes PO_4, and metals; 65-75% of NH_3 removed by air stripping in stripper/absorber column which recovers NH_3 as ammonium sulphate; pH adjusted by H_2SO_4; pumped to process effluent ponds.
	- Leach plant Syn-Gas scrubber recovers NH_3 from purge gas. - HP Still concentrates NH_3 for recycle. - Still Bottoms Evaporator concentrates NH_3 from scrubber bottoms for recycle.	- process sewer collects effluent from process units and discharges to one of three process effluent ponds (11,000 m^3 each). These ponds receive effluent from Agrium as well as treated water from the storm pond system. The effluent ponds are filled, circulated, pH adjusted and tested, and discharged to the river.
Urea plant	- absorption column recovers NH_3 evolved in rectification section for re-use in process. - condenser for NH_3 vapours off NH_3 recovery and crystallization stage.	- urea plant wastewater is directed to the phosphate pond (68,000 m^3) which also handles phosphate granulation scrubber liquor, floor washings and pump gland water. Negative water balance on the phosphate pond will dry it out in 2-5 years by evaporation.
Agrium - Fort Sask. NH_3 plant	- HP condensate steam stripper removes NH_3, MeOH from process cond. before use as boiler feed. - purge gas scrubber for NH_3.	- two storm sewers channel surface water runoff and some process water to Sherritt storm ponds.
Urea plant	- scrubbers reduce NH_3 release to air by scrubbing vented inert gases with water.	- process sewer collects effluent from process units and discharges into Sherritt International effluent ponds.
Agrium - Redwater NH_3 plants	- scrubber for NH_3 recovery from purge gas streams reduces NOx emission as tail gas is used as fuel in primary reformer.	- chemical sewer handles all contaminated process water and discharges to the retention pond (12,000 m^3). Typical contaminants are NH_3, NO_3, and urea. From the retention pond, wastewater is injected in one of two disposal wells.
Urea plant	- scrubbers remove urea particulate and NH_3 from air from granulation section.	- clearwater sewer handles clarifier blowdown, boiler and cooling tower blowdown, sanitary sewer and discharges to the settling pond (10,000 m^3) which continuously discharges to the river.

Appendix A-1
Alberta Fertilizer Plant Comparison of Wastewater Management

	Pollution Control Equipment	Effluent Treatment System
Canadian Fertilizers NH_3 plants	- stripper removes NH_3, etc. from process condensate which is then used in inhibitor mix tank in MEA system. - purge gas chiller condenses NH_3 from purge gas enroute to primary reformer fuel system. Liquid NH_3 is separated and sent to primary ammonia separator for recovery.	- process condensate from NH_3 plants (58,850 kg/hr per plant) and urea plant (14,610 kg/hr) is returned to the clearwell and subsequently to demineralization unit for use as boiler feed. Some clearwell water (28,630 kg/hr) regenerates the resin used to remove minerals. Regen water, contaminated with regen chemicals and NH_3, is impounded in neutralization basins (490 m^3 each) where high and low pH streams mix and neutralize. Further pH adjustment done by adding acid or caustic. Wastewater from neutralization basins is released to equalization basin.
Urea plant	- desorber steam strips NH_3 from process condensate. NH_3 is recycled to synthesis section. - urea in condensate decomposes completely to NH3, CO2 which is carried away with generated steam in HP Condenser. Bottoms are used as scrubber liquid in granulation section. Remainder to clearwell for use as boiler feed.	- the sludge basin (16,660 m^3) removes suspended solids and sludges from clarifier blowdown stream. Effluent from this basin flows to the equalization basin. - the equalization basin (10,220 m^3) receives flows from demin unit, clarifier, cooling tower blowdown,and other miscellaneous plant drains. Retention time is about two days and flow through basin is about 4700 m^3/d. - surface runoff channels to evaporation pond. Depending on the amount of storm water in runoff pond, some of the water is pumped to equalization basin and discharged to river along with process effluent.

Appendix A-2
Comparison of Alberta Ammonia Plants

	Agrium Fort Sask	Sherritt Int'l Fort Sask	Agrium Redwater Ammonia I & Ammonia II	Canadian Fertilizers Limited
Wastewater Generated	process condensate	process condensate	process condensate	process condensate
	boiler water blowdown	boiler water blowdown	boiler water blowdown	boiler water blowdown
	purge gas scrubber liquor	purge gas scrubber liquor	purge gas scrubber liquor	
	cooling water blowdown	cooling water blowdown	cooling water blowdown	water jacket effluent
Contaminants	NH_3, MeOH, CO_2	NH_3, MeOH, CO_2	NH_3, MeOH, CO_2, potassium carbonate, potassium bicarbonate	NH_3, MeOH, CO_2
	Additives: Betz 5712, Betz 5713 (NaOH), Betz Optitrol 6020 (cyclohexylamine, monoethanolamine, dimethylaminopropylamine). Other contaminants:	Additives: Other contaminants:	Additives: Betz 361U (NaOH), Betz 361D, Betz Cortrol 778PC (hydroquinone). Other contaminants: NH_3, MeOH, CO, CO_2, H_2, CH_4, N_2.	Additives: Other contaminants:
	NH_3, H_2, CH_4, N_2, Ar	NH_3, H_2, CH_4, N_2, Ar	NH_3, H_2, CH_4, N_2, Ar	
	Additives: Betz C-86 (NaBr), Cl_2, Betz 29919 (KOH), Betz 2025, H_2SO_4, NaOH Other contaminants:	Additives: Other contaminants:	Additives: Betz 29910 (KOH, 1-H-Benzotriazole), Betz 22105, Betz C-68, Betz C-30 (hexylene glycol, bis(trichloromethyl)sulfone, isopropyl alcohol, methylene bis(thiocyanate), octylphenoxypolyethoxyethanol), Betz 445. Other contaminants:	
Pollution Control	PSA (pressure swing absorption) Waste Gas Scrubber recovers NH_3; HP Condensate Stripper to be installed.	Reuse of contaminated condensate as process steam; scrubbing of purge gas in Leach plant Syn-Gas Scrubber.		Low pressure stripper (plant #1 will have medium pressure stripper by June 1997, plant #2 by June 1999).
Method of Disposal	Condensate is steam stripped and sent to demineralization trains to be used as boiler water makeup.	Process condensate is used as boiler feed in flue gas boiler. Contaminated steam is added to natural gas feed to primary reformer. Excess condensate is discharged to storm pond. Stripped of NH_3, pH adjusted, sent to process effluent system and discharged to river.	The majority of excess steam is condensed and used as boiler feed water. Remaining steam is condensed following CO_2 recovery and is disposed of in a chemical deep well due to contamination with potassium carbonate and potassium bicarbonate.	Process condensate is stripped of NH_3, CO_2, MeOH in low pressure stripper, sent to clearwell (58,850 kg/hr x 2 plants) for use as boiler feedwater or cooling water makeup. Stripped NH_3 sent to reformer flue gas stack; remaining NH_3 to effluent.
	Boiler blowdown discharges to cooling water system (57 kg/min). Additive amounts are: 0.4 kg/day Betz 5712 & 5713, 0.3 kg/day Betz Optitrol 6020.		Boiler blowdown is discharged to the settling pond. Discharge from Ammonia I totals 33.4 kg/min, while discharge from Ammonia II totals 96.3 kg/min.	Boiler blowdown discharges to equalization basin (1630 kg/hr x 2) and subsequently discharged to river.
	Purge gas scrubber liquor is a dilute NH_3 and water mixture called aqua that is reused in the urea plant.	Purge gas is scrubbed in the Leach Plant Syn-Gas Scrubber to recover NH_3. Tail gas is burnt as fuel in Utility I boilers.	Purge gas from both plants is scrubbed with water in Ammonia II to recover NH_3 and treated cryogenically to recover H_2. Tail gas is burnt in the primary reformer.	
	Cooling water blowdown is discharged by Utilities to Utilities I cooling system.	Cooling water blowdown is discharged from Utilities I to the storm pond circuit.	Cooling water blowdown is discharged to the settling pond at a rate of 204 kg/min from Ammonia I via Utilities and 392 kg/min from Ammonia II.	Water jacket effluent discharges to equalization basin (18,600 kg/hr x 2) and subsequently discharged to river.

Appendix A-2

Comparison of Alberta Urea Plants

Urea Plants	Agrium Fort Sask	Sherritt Int'l Fort Sask	Agrium Redwater	Canadian Fertilizers Limited
Wastewater Generated	scrubber bottoms		granulator scrubber liquor	
	water formed in reactions	water produced in the reactions	excess water in the process	process condensate
	boiler water blowdown			boiler water blowdown
	evaporated water in concentration section	condensed vapours from the NH_3 recovery and crystallization sections		condensate from evaporation section
Contaminants	NH_3, CO_2, urea	NH_3, CO_2, urea	urea, biuret, NH_3, formaldehyde	
	NH_3	NH_3, urea	urea, biuret, NH_3	NH_3, urea
	Additives: Betz Optitrol 6020 (cyclohexylamine, monoethanolamine, dimethylaminopropylamine), Betz Optisperse 373 (NaOH). Other contaminants:			
	NH_3			
Pollution Control		blowdown condenser, absorption column		
Method of Disposal	Inert gases vented to atmosphere are scrubbed with water. Ammonia and water mixtures from scrubbers are recycled back to the process.		Scrubber liquor is sent to recycle concentration evaporator where steam and air evaporates water to concentrate liquor for recycle back to evaporators. Air leaving the concentration evaporator is scrubbed with water before being vented. Concentration scrubber liquor is used in the granulation scrubbers.	
	Water formed in the reaction is stripped of ammonia and evaporated to atmosphere.	Produced water is either evaporated or discharged into phosphate ponds. Volume of wastewater is reduced with an evaporator prior to discharge.	Small amount of excess water is discharged to a retention pond and disposed of down a deep well.	Majority of process condensate (14,610 kg/hr) is returned to clearwell for use as boiler feedwater. 1200 kg/hr is discharged to equalization basin and subsequently to the river.
	Boiler water blowdown is discharged to the storm pond at a rate of 57 kg/min. Additive amounts are typically: 0.009 kg/day Betz Optitrol 6020, 0.02 kg/day Betz Optisperse 373.			Boiler water blowdown (1230 kg/hr) is discharged to the equalization basin and subsequently to the river.
	Evaporated water is condensed as aqua (dilute NH_3, H_2O mixture) and steam stripped of NH_3 in urea desorber. Stripped water is used to scrub granulator dust and recycled to evaporator.	Ammonia is recovered from the condensed vapours and the remaining solution is either evaporated or discharged to the phosphate ponds.		Evaporated water is condensed and purified to recover NH_3, CO_2 which is recycled. Purified water is sent to process condensate tank and subsequently to water treatment.

Appendix A-3
Summary of Approval Wastewater Effluent Limits for Alberta Fertilizer Producers

Component or Parameter	Sherritt International - Fort Saskatchewan			Canadian Fertilizers Limited - Medicine Hat			Agrium - Fort Saskatchewan		Agrium - Redwater	
	Maximum Daily Average (average for any month)	One Day Amount (may be exceeded one day a month)	Maximum Daily (never to be exceeded)	Maximum Daily Average (average for any month)	One Day Amount (may be exceeded one day a month)	Maximum Daily (never to be exceeded)	Daily Average Discharge	Annual Discharge	Maximum Daily Average (for any month)	Maximum Daily
	kg/day	kg/day	kg/day	kg/day	kg/day	kg/day	kg/day	tonne/yr	kg/day	kg/day
	*Sherritt manages wastewater from Agrium and Westaim. Limits are therefore combined									
Ammonia (NH_3-N)	505	1010	1515	170	400	700			250	480
	505 (1/1/1996)		1010	170 (1/1/1996)		400			115 (1/10/1999)	250
	280 (1/9/2000)		580	105 (1/9/2000)		250			50 (1/10/2002)	125
	60 (1/9/2005)		150	40 (1/9/2005)		100				
Nitrate (NO_3-N)									240	500
									145 (1/10/1999)	375
									75 (1/10/2002)	250
Organic Nitrogen	284	568	852	80	220	300			50	250
									30 (1/10/1999)	125
									17 (1/10/2002)	65
Phosphate (PO_4)	44	88	132	20	50	100			60	200
									45 (1/10/1999)	140
									35 (1/10/2002)	90
TSS	529	1058	1587	150	350	500			300	800
									235 (1/10/1999)	650
									150 (1/10/2002)	500
Copper (Cu)	1.70	3.40	5.10							
Cyanide (total)	1.50	3.00	4.50							
Chromium (total)	5.5	11.0	16.5							
Cobalt (Co)										
Nickel (Ni)	40	80	120							
Zinc (Zn)										
Iron (Fe)										
Toxicity	Acute lethality test using rainbow trout - more than 50% survival in 100% test sample								96 hr acute lethality using rainbow trout - more than 50% survival in 100% industrial	
pH	6.0-9.5									
Comments:							Agrium FS discharges to Sherritt Int'l			

Appendix A-4
Alberta Fertilizer Plant Comparison of Air Emissions

Company	Plant	Source	Component	Units	Emission Limits	Actual Emissions 1991	1992	1993	1994	1995	1996	1997	Average
Sherritt Int.	Ammonia I	Primary Reformer Stack	NO_x	kg/hr	none	N/R[2]	6.06	5.24	5.29	5.65			
Ft. Sask.	(450 t/d)		NH_3	kg/hr	33.0	N/R[2]	0.40	0.5	0.03	<0.07			0.25
			Methanol	kg/hr	none	N/R[2]	N/D[3]	0	<0.01	<0.01			
	Urea I	Granulation Scrubber Stack	particulate	g/kg	0.20	0.05	0.13	0.01	0.03	0.02			
	(290 t/d)		NH_3	kg/hr	22.5	16.20	18.0	28.8* 13.4	19.7	10.8			15.62
		Absorption Column Exhaust Vent	NH_3	kg/hr	1	0.16	0.27	0.01	0.06	0.01			0.10
		Blowdown Header Exhaust Stack	NH_3	kg/hr	30	27.7	14.3	25.5	31.7* 18.3	12.0			19.6
		Wastewater Evaporator Stack	NH_3	kg/hr	21	N/R[2]	9.45	23.1* 26.1* 7.5	5.35	7.37			7.42
		Combined Emission Limit	NH_3	kg/hr	74.5 (6.17 kg/t)						Combined Emission		42.70 (3.53 kg/t)
		Prill Tower Stacks (2)	NH_3	kg/hr	none	N/R[2]	5.40	11.6	11.13	8.35			
			particulate	g/kg	0.2	N/R[2]	0.10	0.05	0.04	0.03			
	Leach Plant	Stills Bottoms Evaporator Stack	NH_3	kg/hr	25	13.1	1.2	14.6	15.3	20.8/6.7			11.05
		Vent Gas Scrubber	NH_3	kg/hr	30	25.0	69.9* 48.8* 7.6	13.9	3.7	8.33			11.7
	NOTE:	(2.3% of leach plant ammonia emissions is from the ammonia plant)											2.3%(22.75) 0.523
		Combined Emission Limit	NH_3	kg/hr	88 (4.69 kg/t)						Combined Emission		0.773 (0.041 kg/t)
		this combined emission is for Ammonia plant and Leach plant because Leach handles some purge gas from Ammonia plant.											
Agrium	Ammonia	Reformer Stack	NO_x	kg/hr	none	82.5	104.4	80.6	107.4	117.5	79.8		
Ft. Sask.	(1300 t/d)		NH_3	kg/hr	87.5 (1.62 kg/t)	55.6	71.8	71.7	65.7	70.0	57.7		65.4 (1.21 kg/t)
			Methanol	kg/hr	none	68.7	51.3	15.1	166.0	311.5	130.5		
	Urea	Main Stack	NH_3	kg/hr	145 (2.95 kg/t)	43.43	38.74	51.9	51.7	67.0	38.7		48.58 (0.99 kg/t)
	(1180 t/d)		particulate	g/kg	0.20	0.01	0.01	0.08	0.02	0.02	0.04		

Appendix A-4
Alberta Fertilizer Plant Comparison of Air Emissions

Company	Plant	Source	Component	Units	Emission Limits	Actual Emissions 1991	1992	1993	1994	1995	1996	1997	Average
Canadian Fertilizers	Ammonia I (1595 t/d)	Primary Reformer Exhaust Stack	NH_3	kg/hr	79 (1.19 kg/t)			58.82	78.27	65.99	63.81	73.09	68.00 (1.02 kg/t)
			NO_x	kg/hr	none			138.25	122.4	94.92	80.83	126.05	
	Ammonia II (1595 t/d)	Primary Reformer Exhaust Stack	NH_3	kg/hr	79 (1.19 kg/t)			46.8	60.25	49.39	41.73	45.29	48.69 (0.73 kg/t)
			NO_x	kg/hr	none			123.49	162.9	100.89	102.2	127.28	
	Urea Granulation (2035 t/d)	Scrubbers Exhaust Stack	NH_3	kg/hr	220 (2.59 kg/t)		182.8	294.6*	117.8	101.2	183.7	132.6	143.62 (1.69 kg/t)
			particulate	kg/hr	0.2 g/kg			2.9 (0.007 g/kg	6.6 .016 g/kg)	4.6	7.39	39.56	
Agrium Redwater	Ammonia I (690 t/d)	Primary Reformer Exhaust Stacks (2)	NO_x	kg/hr	90	S/D[4]	S/D[4]	S/D[4]	S/D[4]	49.4			
			NH_3	kg/hr	N/L[5]	S/D[4]	S/D[4]	S/D[4]	S/D[4]	<1.0			
	Ammonia II (1890 t/d)	Primary Reformer Exhaust Stack	NO_x	kg/hr	250	90.5	110.7	66.3	61.2	145.8			
			NH_3	kg/hr	N/L[5]	1.1	0.23	0.4	0.037	<1.0			0.44 (0.006 kg/t)
	Urea (1800 t/d)	Urea Synthesis Process Vent Stack	NH_3	kg/hr	85.5	63.37	56.8	71.9	12.9	46.6			50.31
		Urea Granulation Scrubber Stack	NH_3	kg/hr	106.9	93.03	64.77	58.2	57.1	71.3			68.88
		Combined Emission Limit	NH_3	kg/hr	192.4 (2.57 kg/t)						Combined Emission		119.19 (1.59 kg/t)
			particulate	kg/t	0.2	0.05	0.1	0.1	0.09	0.08			
	Ammonium Nitrate (750 t/d)	Ammonium Nitrate Process Vent Stack	NH_3	kg/hr	14.4	28.9* 7.5	7.07	5.4	6.9	9.6			7.29
			particulate	kg/t	0.2	0.01	0.05	0.06	0.06	0.03			
		Prill Tower Scrubber Stack	particulate	kg/t	0.2	0.035	0.044	0.0457	0.017	0.025			

Notes:

1 Asterix indicates non-compliance measurements were reported to AEP. Some of these tests were repeated. Results of the repeated test follow the non-compliance.
2 N/R indicates that a stack test was not required by AEP at that time.
3 N/D indicates that the component was not detected.
4 S/D indicates that Ammonia I plant at Agrium Redwater was shutdown for the entire year.
5 N/L indicates that component must be measured but there is no emission limit.

APPENDIX B

Other Jurisdiction Fertilizer Plants

Appendix B-1
Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
Plant #1	1931	anhydrous ammonia storage and distribution	65000	ammonium sulphate production; aqua ammonia production	cooling water	NH_3		Discharge to river
		ammonium sulphate granulation	110000	100% sold externally	gland water	$(NH_4)_2SO_4$		Discharge to river
					scrubber water	$(NH_4)_2SO_4$	Used as process makeup	
					cooling water	$(NH_4)_2SO_4$		Discharge to river
		ammonium sulphate crystallization	147000	100% sold externally	process condensate	$(NH_4)_2SO_4$, NH_3, SO_2, H_2S	Second effect condensate is used in aqua ammonia production. First effect condensate and scrubber water is used for process water	
					condenser water	$(NH_4)_2SO_4$		
					gland water	$(NH_4)_2SO_4$		
		other sources of WW			sanitary sewer system			Septic fields
					storm sewer system	particulate		Discharge to river
					demineralization system	H_2SO_4, NaOH		Discharge to river
		comments:	Between 1931 and 1994					

Appendix B-1
Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
Plant #2	1968	anhydrous ammonia	430000	100% used on-site in urea plant	process condensate	NH_3, COD, CO_2	Presently none. 100% recycling planned for 1998	Discharged to canal
		solid urea	738000	100% sold externally	condensate from knock out drums	oil, CO_2	Presently none. 100% recycling planned for 1998	Discharged to evaporation pond
					process water	NH_3, urea		Discharged to evaporation pond
		other sources of WW			cooling tower blowdown	SO_4, TDS, TH, Cr(VI), Zn, Cl	Chromium is removed electrochemically and settled in HDPE lined pond for 3 days. pH is adjusted.	Clean water sent to canal
					boiler blowdown	pH (>9), SiO_2	Drained to sewer system	Routed to evaporation pond
					raw water treatment system	pH (>8), TSS	Sludge settled in a pit and removed for landfill.	Clean water used for horticulture / irrigation
					sanitary sewer system	BOD, vegetable oil, detergents		Used for horticulture / irrigation
					storm sewer system	TSS		Used for horticulture / irrigation
					demineralization system	SO_4, TDS, Na, $CaCO_3$, $MgCO_3$, Cl	pH adjusted to between 6 and 9	100% discharged to canal
		comments:	Major improvements are planned for 1998 which will reduce plant emissions and recycle effluent back to the process.					
Plant #3	1992	anhydrous ammonia	580000	77% used in urea production, 23% sold externally	process condensate		Treated by demineralization system and used as boiler feed water	
		solid urea	750000	100% sold externally	process condensate		Treated by demineralization system and used as boiler feed water	

Appendix B-1

Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
		other sources of WW			raw water treatment system		Sludge pumped to evaporation ponds	
					sanitary sewer system		Sewage treatment	Evaporation ponds
					storm sewer system		Collected in storm pond, neutralized and added to raw water supply	Evaporation ponds
					cooling tower blowdown		Urea tower blowdown used as ammonia tower makeup	Evaporation ponds
					demineralization plant wastewater		Used as backwash water or sent to neutralization process	Evaporation ponds

comments: All unusable water from plant process is sent to evaporation ponds. There are no releases.

Appendix B-1
Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
Plant #4	1960	urea ammonium nitrate	29447	100% sold externally	process condensate	NO_3, NH_3, urea	Recovery through vapour recompression evaporation	
		nitric acid	270815	51% to on-site ammonium nitrate plant, 49% sold	process equipment leaks	HNO_3		
					boiler blowdown	HNO_3		
					process condensate	HNO_3	Recovery through vapour recompression evaporation and reused internally	
		ammonium nitrate	175551	100% sold externally	process condensate	NH_3, NH_4NO_3	Recovery through vapour recompression evaporation and reused internally	
		other sources of WW			cooling tower blowdown	NO_3, NH_3, PO_4		Discharged to river
					boiler/compressor blowdown	PO_4	Passes through compartmental settling pond prior to discharge	Discharged to river
					sanitary sewer system		Tile-bed septic system	
					storm sewer system	HNO_3	Partly treated with process wastewater	Most of it discharged to the river
					demineralization system		Neutralization, passes through compartmental settling pond prior to discharge	Discharged to river
					raw water treatment system		Passes through compartmental settling pond prior to discharge	Discharged to river

Appendix B-1
Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
Plant #5	Ammonia - 1986	anhydrous ammonia	256551		process condensate	NH_3	Process condensate is stripped of ammonia in effluent stripper then treated biologically	Discharged to estuary via neutralized effluent sump
	KAM - 1995				boiler blowdown	NH_3, PO_4	Boiler blowdown is stripped of ammonia in effluent stripper then treated biologically	Discharged to estuary via neutralized effluent sump
					pumphouse drains	MEA, NH_3		
		other sources of WW			cooling tower		None	Discharged to estuary via neutralized effluent sump
					boilers/compressors		Stripped of ammonia and treated biologically	Discharged to estuary via neutralized effluent sump
					sanitary sewer system		Sent to septic tank, treated biologically, and clarified	Discharged to estuary via neutralized effluent sump
					storm sewer system		None	Discharged to river via storm sewer system

Appendix B-1

Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
		comments:	Effluent system will be upgraded December 1997 allowing stormwater to be recycled to raw water system. Also, effluent will be batched via retention ponds where it is tested before release. There will be 5 day emergency capacity of 11,000 m^3.					

Appendix B-1

Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
Plant #6	1924	superphosphate	508947	100% sold externally	scrubber bottoms	fluosilicic acid, silica	Fluosilicic acid is recycled partially replacing sulphuric acid. Silica solid recycled as filler in superphosphate	
					sanitary sewer system storm sewer system	solids, F, PO_4, heavy metals	Storm water storage capacity is 5000 m3. In 1996, all storm water was used in superphosphate production	Sent to municipal sewer If storage capacity is overloaded, storm water is treated and discharged into bay
		comments:	phosphogypsum was produced (2,000,000 kg/d) from 1980 to 1990 during production of wet phosphoric acid. 10% was recycled into superphosphate, 90% was sold as soil conditioner. Not currently produced and present stack volume is zero.					

Appendix B-1

Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
Plant #7	1965	anhydrous ammonia	800 tonnes/day	33% used on-site in UAN production, 67% sold off-site	process effluent		Steam stripped and recycled to demineralization unit	NH_3 wastewater sent to 3-cell lagoon. Retention is 1-2 days, undergoes pH control to 6.5-9.0 and is tested before release to river
		urea ammonium nitrate	500 tonnes/day	100% sold externally				UAN wastewater - combined with NH3 wastewater in lagoon
		other sources of WW			cooling tower blowdown	NH_3-N, NO_3-N, organic N		Discharged to a 3-cell lagoon system
					sanitary sewer system	organic N		Combined with NH_3 and UAN wastewaters in lagoon system
					demineralization system	H_2SO_4, NaOH, NO_3-N, Ca	Neutralized by addition of H_2SO_4 and NaOH	Used for pH control of lagoon system
					stormwater collection system			Discharged to a 3-cell lagoon system
					boiler/compressor blowdown		Steam stripped and recycled	
					VOC air stripping tower	toluene, tetrachloroethylene, trichloroethylene, trans 1,2-dichloroethylene	Air used to strip VOCs. Effluent is tested and released	Discharged to river

Appendix B-1
Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
Plant #8	1975	anhydrous ammonia	1135105	70% to UAN plants, 30% sold externally	process condensate and process wastewater	NH_3, CO_2, MeOH. oil NH_3	74% process condensate is recycled (methanol recovery, process condensate polish - ion exchange, then back to NH_3 plant). PCP regen sent to evaporator then to UAN plant. Water in CO_2 is sent to UAN. UAN receives 2% of process wastewater	Non-recycled wastewater (~24% of process water) undergoes oil removal amd neutralization, then sent to settling pond before discharge to the river
		urea solutions	719780	100% to UAN plants				
		urea ammonium nitrate	2117000	2% on-site use, 98% sold externally	process condensate and process wastewater	NH_3, urea, CO_2, NO_3, $NH_4CO_2NH_2$. NH_3, CO_2	Some UAN process effluent is recycled to the process via neutralization and evaporation	Non-recycled wastewater from CO_2 knockout and compressor area drainage go to process sewer, oil removal, neutralization, settling pond, discharge to river
		nitric acid	759200	97% to UAN plants, 3% to other Terra Plant			No process effluent	
		ammonium nitrate	973820	100% to UAN plants			Some process effluent is recycled back to the process after undergoing neutralization and evaporation	Non-recycled wastewater goes to process sewer, oil removal, neutralization, settling pond, discharge to river

Appendix B-1
Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
		other sources of WW			cooling tower blowdown	NH_3, SO_4, Cl, PO_4, Zn, TDS, oil		Coagulation, sedimentation, dechlorination, defoam, discharge to river
					boiler/compressor blowdown	compressor - TDS, oil boiler - PO_4, TDS, Zn, suspended solids	Boiler blowdown - recycled to cooling tower. Some recycled in ion exchange unit	UAN compressor area drainage to process sewer, oil removal, neutralization, settling pond, discharge to river
					raw water treatment system	Cl_2	Makeup water is chlorinated and sent to cooling towers. Anion / ion mixing water is sent to demin water production	Regen from cation/anion beds undergoes neutralization, coagulation, sedimentation, and discharge to river
					sanitary sewer system	Cl_2, fecal coliform		Chlorination, dechlorination, sedimentation, discharge to river
					storm water runoff	TSS, NH_3, NO_3, TKN, phosphorous, oil, grease, Zn		Coagulation, sedimentation, discharge to river
					demineralization system	NH_3, process condensate polish	Process condensate polish regen is recycled to UAN plants after neutralization and evaporation	
					loading area drainage		Some recycled to UAN after neutralization and evaporation	Non-recycled undergoes coagulation, sedimentation, and discharge to river

Appendix B-1

Survey Information for Other Jurisdiction Facilities - Wastewaters Generated

Company and Location	Date of plant opening	Type of plant	Average production (tonnes/year)	Subsequent use	Source of wastewater	Typical contaminants	Applied treatment, reuse and recycle measures	fate of non-recycled streams
					sand filter backwash			Coagulation, sedimentation, discharge to river
	comments:	Technology limits in effect at all times unless river flows are less than 102 ft^3/s in which case water quality limits take effect.						
Plant #9	1974	nitrogen fertilizers			miscellaneous waste water and process wastewater		Oil and water separation, neutralization, Same as above	Discharge to river via Outfall 001A. Outfall
					sanitary sewer system		Same as above	
					stormwater runoff		If contaminated, stormwater is treated as above and discharged via Outfall 001A	If stormwater is not contaminated, it is discharged to river via Outfall 002A

Appendix B-2
Survey Information for Other Jurisdication Facilities - Effluent Limits

Company Name	Year of Data	Outfall or Legislation		Units	Treatment System	Flow (m^3/day)	Frequency of Discharge	NH_3-N (as N)	NO_3-N (as N)	Org-N	Nitrogen, Kjeldahl	PO_4^{3-} (as P_2O_5)	Total Phosphorous	Fluorides (F^-)	Nickel (Ni)	Iron (Fe)	Copper (Cu)
Plant #1	1996																
		Outfall 1	process effluent, storm sewer, demin. Waste	mg/L	no treatment, 1/4 channel diffuser discharge	26000	continuous	12.1									
		Legislation	not provided														
Plant #2	1997																
		Outfall 1		mg/L	no treatment	3544	continuous	142								2.4	
		Outfall 2		mg/L	bank discharge		continuous									140	
		Evaporation		mg/L		1363	continuous	1900								2.6	
		Legislation		mg/L				40						20	1	2	1
Plant #3																	
		Evaporation				600	continuous										
Plant #4	1996																
		Outfall 1	process effluent	mg/L	settling pond, diffuser discharge	1000	continuous	80	110				1.4				0.08
		Outfall 1	process effluent	kg/d		1000	continuous	80	110				1.4				0.023
		Legislation	Outfall 1	kg/d		(proposed limits)		26	27				1.1				0.14
								MAL	MAL				MAL				DL
Plant #5																	
		Outfall 1	stormwater	mg/L			intermittent	1.05									
		Legislation	Outfall 1	mg/L				10									
		Outfall 2	process effluent	mg/L		2000	continuous	2.4									
		Outfall 2	process effluent	kg/d		2000	continuous	4.8									
		Legislation	Outfall 2	mg/L				10									
Plant #6																	
		Outfall 1	stormwater	mg/L			intermittent	100	20				400	300			50
		Legislation	Outfall 1	mg/L		10000 *	pond overflow						100	1	0.5	5	0.1

* expected annual max flow; no flow recorded in 18 months (100% recycle)

Appendix B-2
Survey Information for Other Jurisdication Facilities - Effluent Limits

Company Name	Year of Data	Outfall or Legislation	Cyanide (CN^-)	Cobalt (Co)	Chromium (VI) (Cr^{6+})	TSS	BOD	pH	Oil & Grease	Toxicity	Total Mercury	Total Zinc	Sulphuric Acid (H_2SO_4)	Dissolved SO_4
Plant #1	1996													
		Outfall 1				5.9		7.5			0.0002	0.16	<1	68.8
		Legislation								96 hr LC50 rainbow trout bioassay				
Plant #2	1997													
		Outfall 1				52.8	25	7.5	4.9					863
		Outfall 2				10000	20	7.8						46
		Evaporation			1	17.3		9.7	19.6					133
		Legislation	2		1	150	80	6.0 - 9.0	10					600
Plant #3														
		Evaporation												
Plant #4	1996													
		Outfall 1				18		8.7	1.3					
		Outfall 1				18			1.3					
		Legislation				28		6.0 - 9.5	5					
						MAL			MAL		MAL - monthly average loading; DL - daily loading.			
Plant #5														
		Outfall 1				21.4	5.2	7.1						
		Legislation				40		6.5 - 8.5		96 hr LC50 Rainbow Trout. In 100% effluent concentration, 50% must live				
		Outfall 2				24.2	8.7	7.3						
		Outfall 2				48.4	17.4							
		Legislation				40 (NFR)		6.5 - 8.5		96 hr LC50 Rainbow Trout. In 100% effluent concentration, 50% must live				
Plant #6														
		Outfall 1				200		2	trace					
		Legislation		0.1	0.3	80	0	6.0 to 9.0		96 hr acute lethality of rainbow trout	0.005	0.25		

Appendix B-2
Survey Information for Other Jurisdication Facilities - Effluent Limits

Company Name	Year of Data	Outfall or Legislation	Total Lead	Dissolved Zinc	COD	TDS	Chlorides (Cl^-)	Residual Chlorine	Total Chromium	Fecal Coliforms	Dissolved Oxygen	Temperature (°C)	Cadmium (Cd)	VOCs
Plant #1	1996													
		Outfall 1	0.03	0.13										
		Legislation												
Plant #2	1997													
		Outfall 1			150	1894	319							
		Outfall 2			200	230	20							
		Evaporation			765	4008	114							
		Legislation			150	3500	1000							
Plant #3														
		Evaporation												
Plant #4	1996													
		Outfall 1												
		Outfall 1												
		Legislation												
Plant #5														
		Outfall 1												
		Legislation			10							32		
		Outfall 2												
		Outfall 2												
		Legislation			100							37		
Plant #6														
		Outfall 1												
		Legislation											0.1	

Appendix B-2
Survey Information for Other Jurisdication Facilities - Effluent Limits

Company Name	Year of Data	Outfall or Legislation		Units	Treatment System	Flow (m^3/day)	Frequency of Discharge	NH_3-N (as N)	NO_3-N (as N)	Org-N	Nitrogen, Kjeldahl	PO_4^{3-} (as P_2O_6)	Total Phosphorous	Fluorides (F^-)	Nickel (Ni)	Iron (Fe)	Copper (Cu)
Plant #7	1996																
		Outfall 1	lagoon effluent	mg/L	retention lagoon (1-2 days), pH controlled, pipe discharge	2271	continuous	8	2.4	7.5							
		Outfall 1	lagoon effluent	kg/d		2271	continuous	26	6	19							
		Legislation	Outfall 1	kg/d			30 day avg.	1.1 / 98.0	89.3	47.1							
		Legislation	Outfall 1	kg/d			maximum	2.5 / 196. * winter / summer	204.9	211.4							
		Outfall 2	stripper effluent	mg/L			continuous										
		Outfall 2	stripper effluent	kg/d			continuous		<1.00								
		Legislation	Outfall 2	mg/L													
Plant #8	1996																
		Outfall 1	process effluent	mg/L	coagulation, sedimentation, de-chlorination, de-foam, bank discharge. NH3 plants - oil removal & neutralization; PCP regen - pH adjust	4922	continuous	17.4	4.96	4.5			1.7				
		Outfall 1	process effluent	kg/d		4922	continuous	90	26	23			9				
		Legislation	Outfall 1	mg/L			daily max.		98								
		Legislation	Outfall 1	kg/d			daily avg.	158	125	91			20				
		Legislation	Outfall 1	kg/d			daily max.	310	250	181			39				
Plant #9																	
		Outfall 1	effluent	mg/L		2454	continuous										
		Legislation	Outfall 1	mg/L			monthly avg.										
		Legislation	Outfall 1	mg/L			daily max.										
		Legislation	Outfall 1	kg/d			monthly avg.	622.8		411.4							
		Legislation	Outfall 1	kg/d			daily max.	1208.8		777	1985.9						
		Outfall 2	stormwater														
		Legislation	Outfall 2	mg/L			monthly avg.										
		Legislation	Outfall 2	mg/L			daily max.										
Plant #10																	
		Legislation	Outfall 1	kg/d		3786	30 day avg.	342.7	50.9	286.4							

Appendix B-2
Survey Information for Other Jurisdication Facilities - Effluent Limits

Company Name	Year of Data	Outfall or Legislation	Cyanide (CN^-)	Cobalt (Co)	Chromium (VI) (Cr^{6+})	TSS	BOD	pH	Oil & Grease	Toxicity	Total Mercury	Total Zinc	Sulphuric Acid (H_2SO_4)	Dissolved SO_4
Plant #7	1996													
		Outfall 1												
		Outfall 1						6.5 - 9.0						
		Legislation						6.5 - 9.0		acute - 18.42 TU chronic - 29.78 TU				
		Legislation												
		Outfall 2												
		Outfall 2												
		Legislation						6.5 - 9.0						
Plant #8	1996													
		Outfall 1				6.1		7.2	2.6			0.04		802
		Outfall 1				34			13.2			0.2		
		Legislation				45		6.0 - 9.0	15			1		
		Legislation							37			2.5		
		Legislation							74			5		
Plant #9														
		Outfall 1												
		Legislation							10					
		Legislation				150			15					
		Legislation				145.2								
		Legislation				290.3								
		Outfall 2												
		Legislation						6.0 - 9.0	10					
		Legislation							15					
Plant #10														
		Legislation					50.9	6.0	37.7					

Appendix B-2
Survey Information for Other Jurisdication Facilities - Effluent Limits

Company Name	Year of Data	Outfall or Legislation	Total Lead	Dissolved Zinc	COD	TDS	Chlorides (Cl^-)	Residual Chlorine	Total Chromium	Fecal Coliforms	Dissolved Oxygen	Temperature (°C)	Cadmium (Cd)	VOCs
Plant #7	1996													
		Outfall 1												
		Outfall 1												
		Legislation												
		Legislation												
		Outfall 2												
		Outfall 2												
		Legislation												tetrachloroethylene - 0.005; trichloroethylene - 0.005; trans 1,2-dichloroethylene - 0.07; toluene - 1.00
Plant #8	1996													
		Outfall 1					<0.099			22.3	(org/100ml - 30 day geometric mean)			
		Outfall 1					<0.5			106	(org/100ml - 7 day geometric mean)			
		Legislation					0.099							
		Legislation								200	(org/100ml - 30 day geometric mean)			
		Legislation								400	(org/100ml - 7 day geometric mean)			
Plant #9														
		Outfall 1												
		Legislation												
		Legislation												
		Legislation												
		Legislation												
		Outfall 2												
		Legislation			75									
		Legislation			150									
Plant #10														
		Legislation												

Appendix B-3
Survey Information for Other Jurisdictions - Monitoring Requirements

Company	Plant #1		Plant #2		Plant #3			
Contaminant to be monitored	Frequency	Sample Type	Frequency	Sample Type	Frequency (evaporation pond)	Sample Type	Frequency (stormwater pond)	Sample Type
flow	continuous		frequency and sample type not yet mentioned in laws					
ammonia nitrogen (NH_3-N) (as N)	every 6 days	daily composite	yes		twice per year	composite	twice per year	grab
nitrate nitrogen (NO^-_3-N) (as N)					twice per year	composite	twice per year	grab
total organic nitrogen (org N)								
phosphate (PO_4^{3-}) (as P_2O_5)								
total phosphorous								
fluoride (F^-)					once per year	composite		
nickel (Ni)					once per year	composite		
iron (Fe)			yes		once per year	composite		
copper (Cu)					once per year	composite		
cyanide (CN^-)								
chromium (VI) (Cr^{6+})			yes					
total suspended solids (TSS)	every 6 days	daily composite	yes					
biochemical oxygen demand (BOD)			yes					
pH	every 6 days	daily composite	yes		twice per year	composite		
total organic carbon (TOC)					twice per year	composite	twice per year	grab
uranium (U238)								
total alpha-particles								
total beta-particles								
oil and grease			yes					
toxicity test	quarterly (96 hr LC50 rainbow trout bioassay)	grab sample						

Appendix B-3
Survey Information for Other Jurisdictions - Monitoring Requirements

Company	Plant #1		Plant #2		Plant #3			
Contaminant to be monitored	Frequency	Sample Type	Frequency	Sample Type	Frequency (evaporation pond)	Sample Type	Frequency (stormwater pond)	Sample Type
instream biological testing								
others:								
total mercury (Hg)	every 6 days	daily composite						
dissolved zinc (Zn)	every 6 days	daily composite						
dissolved sulphate (SO_4)	every 6 days	daily composite	yes					
COD			yes					
TDS			yes		twice per year	composite	twice per year	grab
chlorides			yes		twice per year	composite	twice per year	grab
residual chlorine								
dissolved oxygen								
total sulphate (as SO4)					twice per year	composite	twice per year	grab
total zinc					once per year	composite		
total chromium					once per year	composite		
fecal coliforms					twice per year	composite		
total heavy metals								
temperature								
methanol								
specific conductance					twice per year	composite	twice per year	grab
carbonate / bicarbonate					twice per year	composite	twice per year	grab
calcium (Ca)					twice per year	composite	twice per year	grab
magnesium (Mg)					twice per year	composite	twice per year	grab
potassium (K)					twice per year	composite	twice per year	grab
sodium (Na)					twice per year	composite	twice per year	grab
aluminum (Al)					once per year	composite		
cadmium (Cd)					once per year	composite		
manganese (Mn)					once per year	composite		
molybdenum (Mb)					once per year	composite		
selenium (Se)					once per year	composite		
arsenic (As)					once per year	composite		
lead (Pb)					once per year	composite		

Appendix B-3

Survey Information for OtSurvey Information for Other Jurisdictions - Monitoring Requirements

Company	Plant #4		Plant #5				Plant #6		Plant #7	
Contaminant to be monitored	Frequency	Sample Type	Frequency (outfall 1 - storm water to river)	Sample Type	Frequency (outfall 2 - effluent discharge to estuary)	Sample Type	Frequency	Sample Type	Frequency (outfall 1)	Sample Type
flow	daily	continuous			daily (total)	continuous	daily (when flow occurs)	composite	continuous	metered
ammonia nitrogen (NH_3-N) (as N)	daily	composite	weekly	grab	weekly	24 hr composite	daily (when flow occurs)	composite	weekly	grab
nitrate nitrogen (NO^-_3-N) (as N)	daily	composite							weekly	grab
total organic nitrogen (org N)									weekly	grab
phosphate (PO_4^{3-}) (as P_2O_5)										
total phosphorous	weekly	composite					daily (when flow occurs)	composite		
fluoride (F^-)							daily (when flow occurs)	composite		
nickel (Ni)									annual	grab
iron (Fe)										
copper (Cu)	quarterly	composite							annual	grab
cyanide (CN^-)										
chromium (VI) (Cr^{6+})									annual	grab
total suspended solids (TSS)	daily	composite	weekly (NFR - non filterable residue)	grab	weekly (NFR)	24 hr composite				
biochemical oxygen demand (BOD)			quarterly	grab	quarterly	24 hr composite				
pH	daily	continuous	weekly	grab	daily (average)	continuous	daily (when flow occurs)	composite	continuous	metered
total organic carbon (TOC)			semi-annually (TEH - total extractable hydrocarbons)	grab	quarterly (TEH)	24 hr composite				
uranium (U238)										
total alpha-particles										
total beta-particles	weekly	grab								
oil and grease										
toxicity test	monthly (test for toxicity on Daphnia and Trout)	grab	quarterly (rainbow trout 96 hr LC50 bioassay)	grab	quarterly (rainbow trout 96 hr LC50 bioassay)	24 hr composite	monthly (96 hr acute lethality of rainbow trout)	composite	acute - quarterly chronic - quarterly	composites

Appendix B-3

Survey Information for OtSurvey Information for Other Jurisdictions - Monitoring Requirements

Company	Plant #4		Plant #5				Plant #6		Plant #7	
Contaminant to be monitored	Frequency	Sample Type	Frequency (outfall 1 - storm water to river)	Sample Type	Frequency (outfall 2 - effluent discharge to estuary)	Sample Type	Frequency	Sample Type	Frequency (outfall 1)	Sample Type
nstream biological testing										
thers:										
otal mercury (Hg)										
issolved zinc (Zn)										
issolved sulphate (SO_4)										
COD			weekly	grab	weekly	24 hr composite				
TDS										
hlorides										
esidual chlorine										
issolved oxygen									weekly	grab
otal sulphate (as SO4)										
otal zinc										
otal chromium										
ecal coliforms										
otal heavy metals										
emperature			weekly	grab	daily (average)	continuous				
nethanol			weekly	grab	weekly	24 hr composite				
pecific conductance			weekly	grab	weekly	24 hr composite				
arbonate / bicarbonate										
alcium (Ca)										
nagnesium (Mg)										
otassium (K)										
odium (Na)										
luminum (Al)										
admium (Cd)										
nanganese (Mn)										
olybdenum (Mb)										
elenium (Se)										
rsenic (As)										
ead (Pb)										

Appendix B-3

Survey Information for Ot Survey Information for Other Jurisdictions - Monitoring Requirements

Company	Plant #8		Plant #9				Plant #10	
	Frequency (outfall 1)	Sample Type	Frequency (Outfall 1)	Sample Type	Frequency (Outfall 2)	Sample Type	Frequency (Outfall 1)	Sample Type
Contaminant to be monitored								
flow	daily	continuous	continuous	rc recorder	once per month	estimation	daily	continuous
ammonia nitrogen (NH_3-N) (as N)	twice per week	24 hr composite	3 times per week	24 hr composite	once per month	grab	daily	24 hr composite
nitrate nitrogen (NO^-_3-N) (as N)	twice per week	24 hr composite	3 times per week	24 hr composite			daily	24 hr composite
total organic nitrogen (org N)	twice per week	24 hr composite	3 times per week	24 hr composite			daily	24 hr composite
phosphate (PO_4^{3-}) (as P_2O_5)								
total phosphorous	twice per week	24 hr composite						
fluoride (F^-)								
nickel (Ni)								
iron (Fe)								
copper (Cu)								
cyanide (CN^-)								
chromium (VI) (Cr^{6+})								
total suspended solids (TSS)	twice per week	24 hr composite	3 times per week	24 hr composite				
biochemical oxygen demand (BOD)							once per two weeks	24 hr composite
pH	daily	continuous	continuous	rc recorder	once per month	grab	daily	grab
total organic carbon (TOC)								
uranium (U238)								
total alpha-particles								
total beta-particles								
oil and grease	twice per week	grab	3 times per week	grab	once per month	grab	once per week	grab
toxicity test								once per year

Appendix B-3

Survey Information for OtSurvey Information for Other Jurisdictions - Monitoring Requirements

Company	Plant #8		Plant #9				Plant #10	
	Frequency (outfall 1)	Sample Type	Frequency (Outfall 1)	Sample Type	Frequency (Outfall 2)	Sample Type	Frequency (Outfall 1)	Sample Type
Contaminant to be monitored								
instream biological testing								
others:								
total mercury (Hg)								
dissolved zinc (Zn)	twice per week	24 hr composite						
dissolved sulphate (SO_4)								
COD					once per month	grab		
TDS								
chlorides								
residual chlorine	twice per week	grab						
dissolved oxygen								
total sulphate (as SO4)	twice per week	grab						
total zinc								
total chromium								
fecal coliforms	5 times/30 days	grab						
total heavy metals								
temperature			continuous	rc recorder				
methanol								
specific conductance								
carbonate / bicarbonate								
calcium (Ca)								
magnesium (Mg)								
potassium (K)								
sodium (Na)								
aluminum (Al)								
cadmium (Cd)								
manganese (Mn)								
molybdenum (Mb)								
selenium (Se)								
arsenic (As)								
lead (Pb)								

APPENDIX C

Fertilizer Plant Facility Survey

Alberta
ENVIRONMENTAL PROTECTION

SURVEY
of
LIQUID EFFLUENT DISCHARGES
in the
FERTILIZER MANUFACTURING INDUSTRY

Instructions:

1. **Complete the survey**

2. **Upon completion, please fax your results to:**
   Brian Yaremko, P.Eng.
   Alberta Environmental Protection
   Edmonton, Alberta, Canada
   (403) 422-9714

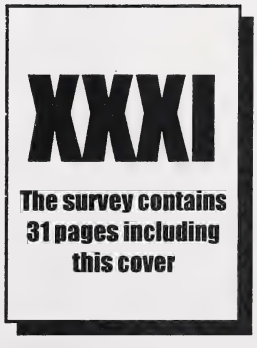
2. **Return the completed survey by mail to**
   Alberta Environmental Protection
   Standards & Guidelines Branch
   6th floor, Oxbridge Place
   9820 - 106 Street NW
   Edmonton, Alberta, Canada
   T5K - 2J6
   attention: Brian Yaremko, P.Eng.

3. **If you have any questions whatsoever, please contact**

   Brian Yaremko, P.Eng.
   Consultant, Standards & Guidelines Branch
   (403) 427-8540 (direct)
   (403) 422-9714 (fax)
   guest4@env.gov.ab.ca (e-mail)

   or

   Prasad Valupadas, P.Eng.
   Engineer, Standards & Guidelines Branch
   (403) 427-8565 (direct)
   (403) 422-9714 (fax)



1. general information

name of company	
name of plant	
date of plant opening	
mailing address of plant	
city	
postal/zip code	
telephone	
fax	
name of contact	

2. summary of production

Please identify those products which are manufactured at your plant by describing:

- your plant's typical annual production of each product (as appropriate)
- your plant's nominal design production capacity of each product
- the subsequent uses/fates of each product
- the year of which the reported production data are representative

An example has been provided for each of the nitrogen and phosphorous plant-types.
Note that total phosphoric acid production is commonly expressed in terms of P_2O_5 - please follow this convention if possible.
Space has been provided for you to add any fertilizer products not already included in these tables.

a) nitrogen plants:

These numbers represent production data for the year 199__

product	name of process	average production	year	subsequent use
e.g. ammonia	*partial oxidation process*	*40000 tonnes/year*	*1993*	*35% to on-site urea plant ; 65% sold externally*
anhydrous ammonia				
solid urea				
polymer coated urea				
urea solutions				
urea ammonium nitrate				
nitric acid				
ammonium nitrate				
ammonium sulphate				

b) phosphorous plants:

These numbers represent production data for the year 199__

product	name of process	average production	year	subsequent use
e.g. phosphoric acid	*wet process*	*250 tonnes/year (as P_2O_5)*	*1996*	*100% to on-site MAP plant*
phosphoric acid				
mono ammonium phosphate(MAP)				
sulphuric acid				
normal superphosphate				
triple superphosphate				
phosphogypsum				

c) additional, other:

These numbers represent production data for the year 199__

product	name of process	average production	year	subsequent use
potassium chloride				
potassium sulphate				
other:				
other:				

3. Generation of wastewaters by individual component processes

This section is intended to characterize the process wastewaters *after* they are generated by the individual process, but *before* they enter a final effluent stream for disposal/release to the environment. Both the quality of the individual process wastewaters and the general effluent handling measures within each component process will be addressed.

a) sources of individual process wastewaters

For each individual source of wastewater in your facility, please describe verbally the contaminants which are generated - an example is provided. Subsequently, these contaminants may be recycled directly to other processes within the facility, they may be sent to holding tanks/ponds for disposal or later recycle, or they may be discharged directly to the plant's final effluent. Such reuse/recycle methods will be addressed later in this survey.

(↕) source of wastewater:	(↔) typically generated contaminants:
e.g. ammonia plant	*- process condensate: N2, H2, some CH4, some NH3, someCO ; blowdown: Ni, Sb, Pd (catalysts), ammonia*
e.g. H_2SO_4 plant	*- vanadium (from catalysts), boiler blowdown: H2S04, SO3, SO2*
ammonia plant	
urea plant	
urea-NH_4NO_3 plant	
nitric acid plant	
NH_4NO_3 plant	
$(NH_4)_2SO_4$ plant	

phosphoric acid plant	
H_2SO_4 plant	
$NH_4H_2PO_4$ (MAP) plant	
superphosphate plant	
cooling tower blowdown	
boiler/ compressor blowdown	
raw water treatment system	
sanitary sewer system	
storm sewer system	
demineralization system	
received from other industries	
potassium chloride plant	
potassium sulphate plant	
other:	
other:	

b) general treatment, reuse and recycle measures for individual plant processes and waste streams

Alberta Environmental Protection would also like to identify the treatment, reuse and recycle processes which are applied within each plant, *upstream* of where each **individual** process wastewater is released/disposed of to the environment. Such processes ultimately lead to a reduction in both the overall contaminant levels and overall quantity of the ***final*** combined wastewater streams from the entire plant as a whole. Typical examples are: process condensate treatment by stripping followed by reuse/recycle; transfer of process water elsewhere in the plant for use as cooling water; reclamation of blowdown water for use in steam generation; transfer of unstripped condensates directly back to the reactor vessels. Of particular interest are any closed-loop effluent recycle practices (along with their accompanying in-line treatment processes).

Please complete the following tables, as appropriate, according to the following example:

***e.g.*: a nitrogen fertilizer plant producing both ammonia and urea:**

source	*type*	*applied treatment, reuse and recycle measures*	*fate of non-recycled wastewater streams*
ammonia plant	*process effluent*	*- some process condensate is recycled back through the shift converter as quenching water*	*- all non-recycled process condensate is released to a settling pond before final discharge to the river*
urea plant	*process effluent*	*- scrubber liquor from the granulator scrubbers is concentrated in an evaporator and is recycled back through the prilling tower.*	*- all non-recycled scrubber liquor enters the sanitary sewer for treatment in on-site lagoons*
cooling tower(s)	*blowdown*	*- all blowdown is treated for metals removal in the demineralization train, enters the effluent pond and is recycled back into the plant service water*	*- all non-recycled blowdown enters the retention pond just before it is deep-well injected*

The *overall* final effluent wastewater - which comprises all *individual* component process wastewaters which are not recycled internally - represents the net generation of wastewater for the plant as a whole, and it is this wastewater that must be released or disposed of to the environment. The overall final effluent wastewater will be addressed in a later section of this survey.

CONTINUED...

i) nitrogen plants

source	type	applied treatment, reuse and recycle measures	fate of non-recycled wastewater streams
ammonia plant	process effluent		
solid urea plant	process effluent		
urea ammonium nitrate plant	process effluent		
nitric acid plant	process effluent		
ammonium nitrate plant	process effluent		
ammonium sulphate plant	process effluent		

ii) phosphorous plants

source	type	applied treatment, reuse and recycle measures	fate of non-recycled wastewater streams
phosphoric acid plant	process effluent		
sulphuric acid plant	process effluent		
mono-ammonium phosphate (MAP) plant	process effluent		
normal superphosphate plant	process effluent		
triple superphosphate plant	process effluent		
phosphoric acid plant	phosphogypsum slurry		

iii) general, other

source	type	applied treatment, reuse and recycle measures	fate of non-recycled wastewater streams
cooling tower(s)	blowdown		
boiler(s) and compressor(s)	blowdown		
various	cooling water (in general)		
raw water treatment system	effluent & sludge		
sanitary sewer system	general domestic sewage		
stormwater collection system	general surface runoff		
demineralization systems	effluent & sludge		
other industries	process effluent (accepted by prior		
potassium chloride	process effluent		
potassium sulphate	process effluent		
other:			
other:			

4. Generation of Final Effluent

Alberta Environmental Protection wishes to define which individual effluent streams contribute to the *final* effluent stream or streams. In general, four individual waste streams can be identified: process wastewater (including condensates, blowdowns, demineralization water, cooling water); sanitary wastewater (including sewage, domestic washwater); stormwater (including surface runoff from the plant site); and effluents accepted from other facilities (by prior agreement). Variations commonly occur, as these waste streams are often interconnected in practice. For instance, all of the individual streams may be combined (in a large retention pond, for example) and then disposed of together via a common outlet; some individual effluent streams may receive extra treatment before mixture and common final release with the other streams; each individual stream may be subjected separately to specific final treatment steps before each is disposed of its own separate outfall; the final combined plant wastewater may be partially recycled to some process or processes lying upstream, while the remainder is disposed of to the river.

a) general operations

Please select (✔) the general description that best describes your plant:

- ☐ process wastewater, sanitary sewer wastewater and storm sewer wastewater are collected together into one or more common pipes and are disposed of without recycle or further treatment
- ☐ process wastewater, sanitary sewer wastewater and storm sewer wastewater are collected together into one or more common pipes; some of this efluent is recycled while the rest is disposed of without further treatment
- ☐ process wastewater, sanitary sewer wastewater and storm sewer wastewater all drain into one or more common retention ponds; the combined wastewater is eventually disposed of without recycle
- ☐ process wastewater, sanitary sewer wastewater and storm sewer wastewater all drain into one or more common retention ponds; some of this combined wastewater is recycled, while the remainder is disposed of
- ☐ process wastewater is disposed of directly, without recycle or further treatment; sanitary sewer wastewater and storm sewer wastewater are collected, treated and released separately elsewhere (*e.g.* into the municipal storm sewer system)
- ☐ some process wastewater is recycled while the rest is disposed of directly; sanitary sewer wastewater and storm sewer wastewater are collected, treated and released separately elsewhere (*e.g.* into the municipal storm sewer system)
- ☐ process wastewater drains into a holding pond and is eventually disposed of without recycle; sanitary sewer wastewater and storm sewer wastewater are collected, treated and released separately elsewhere (*e.g.* into the municipal storm sewer system)
- ☐ process wastewater drains into a holding pond; some is recycled, while the remainder is disposed of; sanitary sewer wastewater and storm sewer wastewater are collected, treated and released separately elsewhere (*e.g.* into the municipal storm sewer system)
- ☐ other (please describe briefly):

_____
_____
_____
_____
_____
_____

b) summary of potential effluent handling/disposal methods

Please indicate the number of separate final wastewater streams which are directed to each of the following typical wastewater handling/disposal methods. Here, *regulated* streams are those wastewater streams which must by law be monitored, while *unregulated* implies those wastewater streams for which monitoring is not required - legislation and monitoring will be considered later in this survey.

e.g. *a combined ammonia-urea plant discharges ½ of its net process wastewater (from both plants combined)to the river via a single outfall; another wastewater stream (not an outfall, as it does not release to a river, lake or other body of water) conveys ¼ of the net process wastewater to deep-well injection, while the other ¼ of the net process wastewater is recycled by yet another line to the front-end of the plant for reintroduction as process water; two other wastewater lines convey combined domestic sewage and stormwater from the plant to the local municipal sewer. Only the single outfall to the river is monitored. (Note that 2 different process wastewaters from 2 separate plants give rise to a single outfall to the river)*

➔ ***total number of separate, final wastewater streams: 5***

target of final effluent/wastewater streams (final wastewater handling/disposal method):	*number of wastewater streams (regulated)*	*number of wastewater streams (unregulated)*
released to river (outfall)	*1*	
deep-well injection		*1*
transferred to municipal sewer		*2*
recycled to upstream plant processes		*1*

➔ **total number of separate, final wastewater streams: _____**

target of final effluent/wastewater streams (final wastewater handling/disposal methods):	**number of wastewater streams (regulated)**	**number of wastewater streams (unregulated)**
released to river (outfall)		
deep-well injection		
land application / irrigation		
transferred to municipal sewer		
released to evaporation ponds		
released to long-term storage tanks/ponds		
recycled to upstream plant processes		
other:		
other:		

c) summary of general effluent management practices

Please identify (✔) the **individual** process wastewaters which ultimately constitute each of the **final** effluent/wastewater streams identified in section *4.b* above. To reiterate, the *overall* final effluent wastewater comprises all *individual* component process wastewaters which are not recycled internally and represents the net generation of wastewater for the plant as a whole, and it is this wastewater that must be released or disposed of to the environment. Should an individual source contribute nothing to the final overall plant effluent (i.e. if it contributes nothing to the final effluent/wastewater due to 100% internal recycling), please identify it accordingly.

(↕) contributing individual sources of facility's overall wastewater streams:	(↔) final wastewater stream(s):					(↔) no contribution - zero discharge:	
	to outfall 1	to outfall 2	to outfall 3	to outfall 4	to outfall 5	(100% internal recycle)	(100% recycle to other plant processes or sites)
ammonia plant process water							
urea plant process water							
nitric acid plant process water							
ammonium sulphate plant process water							
ammonium nitrate plant process water							
phosphoric acid plant process water							
sulfuric acid plant process water							
$NH_4H_2PO_4$ (MAP) plant process water							
superphosphate plant process water							
cooling tower blowdown							
boiler/compressor blowdown							
raw water treatment system							
sanitary sewer system							
storm sewer system							
demineralization system							
wastewater received from other industries							
potassium chloride plant process water							
potassium sulphate plant process water							
other:							
other:							

(↕) contributing individual sources of facility's overall wastewater streams:	(↔) final wastewater stream(s):					(↔) no contribution - zero discharge:	
	to deep-well injection	to land application	to long-term storage	to municipal sewer	to evaporation	(100% internal recycle)	(100% recycle to other plant processes or sites)
ammonia plant process water							
urea plant process water							
nitric acid plant process water							
ammonium sulphate plant process water							
ammonium nitrate plant process water							
phosphoric acid plant process water							
sulfuric acid plant process water							
$NH_4H_2PO_4$ (MAP) plant process water							
superphosphate plant process water							
cooling tower blowdown							
boiler/compressor blowdown							
raw water treatment system							
sanitary sewer system							
storm sewer system							
demineralization system							
wastewater received from other industries							
potassium chloride plant process water							
potassium sulphate plant process water							
other:							
other:							

comments: _____
_____
_____
_____

d) typical final effluent / wastewater treatment systems

The overall **final** wastewater streams for the plant may be subjected to various treatment or polishing steps between the generation of the wastewater (upstream), and the ultimate disposal/release of the wastewater (downstream) to the environment. These treatment processes may include: physical treatment processes such as filters, screens, detention ponds and simple gravity settling; chemical treatment processes such as pH adjustment, disinfection; or biological treatment processes such as aeration, activated sludge, aerobic treatment, anaerobic treatment.

Please describe any such treatment processes applied to each of the final effluent/wastewater streams identified previously (along with a brief statement of how the resultant solid wastes are managed).

e.g. **an excess process wastewater (effluent) destined for deep-well injection:**

- *consists of process wastewaters from both the ammonia and urea plants, along with a contribution from the sanitary sewer; it is introduced to a settling pond (detention time 3 days) where it is subjected to pH adjustment followed by gravity settling; some of the resultant clarified supernatant is recycled back to the plant as boiler water, and the sludge and bottom water are released directly to deep well injection*

target of final effluent/wastewater stream (manner of release to the environment):	physical, chemical and biological treatment processes applied before release to environment
released to outfall 1	
released to outfall 2	
released to outfall 3	
released to outfall 4	
released to outfall 5	
released to deep-well injection	

released to land application / irrigation	
transferred to municipal sewer	
released to evaporation ponds	
released to long-term storage tanks/ponds	
recycled back to upstream plant processes	
other:	
other:	

e) final effluent and final wastewater streams - measured flows

Please provide the typical daily flow rates for each effluent/wastewater stream identified above. Again, tables are provided for numerous potential effluent handling/disposal methods - complete only those which apply to your facility.

i) <u>final effluent stream to outfall (aquatic disposal)</u>

→ this stream discharges:
- ☐ 1. continuously
- ☐ 2. intermittently (batch)
- ☐ 3. other (please explain):

_____
_____
_____
_____

→ What is the name of the receiving river, lake or body of water to which this stream is released?

_____

→ What type of discharge to the receiving watercourse is practiced? (*e.g.* bank discharge, mid-channel diffuser or diffusers)?

_____

→ If you indicated intermittent (batch) operation above, please indicate the typical number of effluent release episodes per year to the receiving watercourse: _____

→ **EFFLUENT BALANCE** - please define **both** the average net <u>volume</u> of wastewater generated daily by all contributing upstream plant sources and directed into this final effluent stream, **and** the <u>rate</u> at which this liquid effluent is subsequently disposed of to the environment. The difference between these 2 rates should represent the rate at which this final effluent stream is recycled back to upstream locations in the facility:

liquid effluent <u>production</u>	**rate:**	
	(volume/day)	**(volume/year)**
net liquid effluent to outfall generated by all upstream sources		

liquid effluent <u>disposal/release</u> method	**rate:**	
	(volume/day)	**(volume/year)**
net rate of aquatic release (end-of-pipe)		
effluent recycled back to plant		

☞ if your plant discharges to more than one licenced outfall line, please photocopy this sheet and complete it for each additional outfall as appropriate.

ii) **final effluent stream to deep well injection (if applicable)**

→ this stream discharges:
- ☐ 1. continuously
- ☐ 2. intermittently (batch)
- ☐ 3. other (please explain):

_____
_____
_____
_____

→ If you indicated intermittent (batch) operation above, please indicate the typical number of effluent release episodes per year : _____

→ **EFFLUENT BALANCE** - please define **both** the average net volume of wastewater generated daily by all contributing upstream plant sources and directed into this final effluent stream, **and** the rate at which this liquid effluent is subsequently disposed of to the environment. The difference between these 2 rates should represent the rate at which this final effluent stream is recycled back to upstream locations in the facility:

liquid effluent production	**rate:**	
	(volume/day)	**(volume/year)**
net liquid effluent to deepwell generated by all upstream sources		

liquid effluent disposal/release method	**rate:**	
	(volume/day)	**(volume/year)**
net rate of deep-well release		
effluent recycled back to plant		

☞ if your plant discharges to more than one licenced deep-well injection line, please photocopy this sheet and complete it for each additional deep-well injection line as appropriate.

iii) **final effluent stream to land application/irrigation (if applicable)**

➔ this stream discharges:
- ☐ 1. continuously
- ☐ 2. intermittently (batch)
- ☐ 3. other (please explain):

_____
_____
_____

➔ If you indicated intermittent (batch) operation above, please indicate the typical number of effluent release episodes per year : _____

➔ **EFFLUENT BALANCE** - please define **both** the average net volume of wastewater generated daily by all contributing upstream plant sources and directed into this final effluent stream, **and** the rate at which this liquid effluent is subsequently disposed of to the environment. The difference between these 2 rates should represent the rate at which this final effluent stream is recycled back to upstream locations in the facility:

liquid effluent production	**rate:** (volume/day)	(volume/year)
net liquid effluent to land application/irrigation generated by all upstream sources		

liquid effluent disposal/release	**rate:** (volume/day)	(volume/year)
net rate of land application/irrigation		
effluent recycled back to plant		

☞ if your plant discharges to more than one licenced land application/irrigation line, please photocopy this sheet and complete it for each additional licenced land application/irrigation line, as appropriate.

iv) final effluent stream to municipal sewer (if applicable)

→ this stream discharges:
- ☐ 1. continuously
- ☐ 2. intermittently (batch)
- ☐ 3. other (please explain):

_____
_____
_____
_____

→ If you indicated intermittent (batch) operation above, please indicate the typical number of effluent release episodes per year : _____

→ **EFFLUENT BALANCE -** please define **both** the average net volume of wastewater generated daily by all contributing upstream plant sources and directed into this final effluent stream, **and** the rate at which this liquid effluent is subsequently disposed of to the environment. The difference between these 2 rates should represent the rate at which this final effluent stream is recycled back to upstream locations in the facility:

liquid effluent production	**rate:**	
	(volume/day)	**(volume/year)**
net liquid effluent generated by all upstream sources and transferred to municipal sewer		

liquid effluent disposal/release	**rate:**	
	(volume/day)	**(volume/year)**
net rate of transfer to municipal sewer		
effluent recycled back to plant		

☞ if your plant transfers effluent/wastewater to the municipal sewer via more than one licenced effluent line, please photocopy this sheet and complete it for each additional licenced effluent line as appropriate.

v) **final effluent stream release to long-term holding tanks/ponds (if applicable)**

→ this stream discharges:
- ☐ 1. continuously
- ☐ 2. intermittently (batch)
- ☐ 3. other (please explain):

_____
_____
_____
_____

→ If you indicated intermittent (batch) operation above, please indicate the typical number of effluent release episodes per year : _____

→ **EFFLUENT BALANCE** - please define **both** the average net volume of wastewater generated daily by all contributing upstream plant sources and directed into this final effluent stream, **and** the rate at which this liquid effluent is subsequently disposed of to the environment. The difference between these 2 rates should represent the rate at which this final effluent stream is recycled back to upstream locations in the facility:

liquid effluent production	**rate:**	
	(volume/day)	**(volume/year)**
net liquid effluent to long-term holding tanks/ponds generated by all upstream sources		

liquid effluent disposal/release	**rate:**	
	(volume/day)	**(volume/year)**
net rate of liquid effluent release to long-term holding tanks/ponds		
effluent recycled back to plant		

☞ if your plant discharges to more than one licenced long-term storage facility, please photocopy this sheet and complete it for each additional licenced licenced long-term storage facility, as appropriate.

vi) final effluent stream release to evaporation ponds (if applicable)

➔ this stream discharges:
- ☐ 1. continuously
- ☐ 2. intermittently (batch)
- ☐ 3. other (please explain):

_____
_____
_____
_____

➔ If you indicated intermittent (batch) operation above, please indicate the typical number of effluent release episodes per year : _____

➔ **EFFLUENT BALANCE** - please define **both** the average net volume of wastewater generated daily by all contributing upstream plant sources and directed into this final effluent stream, **and** the rate at which this liquid effluent is subsequently disposed of to the environment. The difference between these 2 rates should represent the rate at which this final effluent stream is recycled back to upstream locations in the facility:

liquid effluent production	**rate:**	
	(volume/day)	**(volume/year)**
net liquid effluent to evaporation ponds generated by all upstream sources		

liquid effluent disposal/release	**rate:**	
	(volume/day)	**(volume/year)**
net rate of liquid effluent release to evaporation ponds		
effluent recycled back to plant		

☞ if your plant transfers effluent/wastewater to evaporation ponds via more than one licenced effluent line, please photocopy this sheet and complete it for each additional licenced effluent line to evaporation ponds, as appropriate.

5. Final Effluent - measured contaminant levels

Please characterize each of the **FINAL** combined effluent/wastewater streams from your facility based upon your own monitoring data. Annually averaged typical daily release data are requested if possible. Units of milligrams per litre (mg/l) and kilograms per day (kg/d) are indicated, although any set of units may be used as your situation dictates. As well, depending upon your particular plant, you may monitor concentrations (mg/l), mass-loadings (kg/d) or both - columns are provided for each.

a) effluent released via aquatic disposal ➔ *i.e.* outfalls

The data in this table represent average values for the year 199___

(↕) CONTAMINANTS:	outfall 1		outfall 2		outfall 3	
	mg/l	kg/d	mg/l	kg/d	mg/l	kg/d
ammonia nitrogen (NH_3-N) (as N)						
nitrate nitrogen (NO^-_3-N) (as N)						
total organic nitrogen (org N)						
phosphate (PO_4^{3-}) (as P_2O_5)						
total phosphorous						
fluoride (F^-)						
nickel (Ni)						
iron (Fe)						
copper (Cu)						
cyanide (CN^-)						
chromium (VI) (Cr^{6+})						
total suspended solids (TSS)						
biochemical oxygen demand (BOD)						
pH						
oil & grease						
other:						
other:						
other:						
other:						

Please make additional copies of this sheet should you have more than 3 outfalls at your facility.

b) non-aquatic disposal

The data in this table represent average values for the year 199___

(↕) CONTAMINANTS:	deep-well injection		land application		long-term storage tanks/ponds	
	mg/l	kg/d	mg/l	kg/d	mg/l	kg/d
ammonia nitrogen (NH_3-N) (as N)						
nitrate nitrogen (NO^-_3-N) (as N)						
total organic nitrogen (org N)						
phosphate (PO_4^{3-}) (as P_2O_5)						
total phosphorous						
fluoride (F^-)						
nickel (Ni)						
iron (Fe)						
copper (Cu)						
cyanide (CN^-)						
chromium (VI) (Cr^{6+})						
total suspended solids (TSS)						
biochemical oxygen demand (BOD)						
pH						
oil & grease						
other:						
other:						
other:						
other:						

CONTINUED...

The data in this table represent average values for the year 199___

(‡) CONTAMINANTS:	discharge to municipal sewer		evaporation		other _____	
	mg/l	kg/d	mg/l	kg/d	mg/l	kg/d
ammonia nitrogen (NH_3-N) (as N)						
nitrate nitrogen (NO^-_3-N) (as N)						
total organic nitrogen (org N)						
phosphate (PO_4^{3-}) (as P_2O_5)						
total phosphorous						
fluoride (F^-)						
nickel (Ni)						
iron (Fe)						
copper (Cu)						
cyanide (CN^-)						
chromium (VI) (Cr^{6+})						
total suspended solids (TSS)						
biochemical oxygen demand (BOD)						
pH						
oil & grease						
other:						
other:						
other:						
other:						

6. Legislation

a) general

name of legislative authority: _____

b) legislated monitoring requirements

number of separately regulated effluent/wastewater streams: _____

e.g. the description of monitoring requirements governing the monitoring of 1 of 2 effluent wastewater streams to 1 of 2 operational outfalls in an ammonia plant:

the following legislated monitoring requirements apply to:

- ☑ *outfall stream 1 of 2*
- ☐ *deep-well stream ___ of ___*
- ☐ *storage stream ___ of ___*
- ☐ *land application stream ___ of ___*
- ☐ *land application stream ___ of ___*
- ☐ *evaporation stream ___ of ___*
- ☐ *stream to municipal sewer ___ of ___*
- ☐ *other _____*

contaminants to be monitored for	*frequency*	*sample type*
ammonia nitrogen (NH_3-N) (as N)	*daily*	*composite*
pH	*daily*	*continuous*
flow	*daily*	*continuous*
nitrate nitrogen (NO^-_3-N) (as N)	*daily*	*composite*
total organic nitrogen (org N)	*daily*	*composite*
total phosphorous	*daily*	*composite*
instream biological testing (specify): 96-hour acute lethality of rainbow trout	*monthly*	*composite*

Note that if this fictitious plant had 3 or more separate, individually regulated outfalls, it would be indicated above as 1 of 3, or 1 of 4, or 1 of 5....

The following tables (both for this section 6.b, and for next section 6.c) are very intended to be very general in their applicability and can be used for description of any final effluent/wastewater stream directed to any of the possible effluent handling/disposal methods considered here.

Only a single table is provided. Please photocopy it accordingly - one for each separate, distinct final wastewater stream that is released to the environment.

Please enter your actual data in the following table. Copy this table as appropriate for so that monitoring requirements for each of your facility's independently regulated effluent/wastewater disposal streams may be defined.

the following legislated monitoring requirements apply to:

- ☐ outfall stream ___ of ___
- ☐ deep-well stream ___ of ___
- ☐ storage stream ___ of ___
- ☐ land application stream ___ of ___
- ☐ land application stream ___ of ___
- ☐ evaporation stream ___ of ___
- ☐ stream to municipal sewer ___ of ___
- ☐ other _____

contaminants to be monitored for	frequency	sample type
flow		
ammonia nitrogen (NH_3-N) (as N)		
nitrate nitrogen (NO^-_3-N) (as N)		
total organic nitrogen (org N)		
phosphate (PO_4^{3-}) (as P_2O_5)		
total phosphorous		
fluoride (F^-)		
nickel (Ni)		
iron (Fe)		
copper (Cu)		
cobalt (Co)		
cyanide (CN^-)		
chromium (VI) (Cr^{6+})		
total suspended solids (TSS)		
biochemical oxygen demand (BOD)		
pH		
total organic carbon (TOC)		
uranium (U238)		
total α-particles		
total β-particles		
oil & grease		
toxicity test(specify):		
instream biological testing (specify):		
other:		
other:		
other:		
other:		

c) legislated water-quality limits

Copy this table as appropriate for so that water quality limits upon each of your facility's independently regulated effluent/wastewater disposal streams may be defined.

the following legislated water-quality limits apply to:

- ☐ outfall stream ___ of ___
- ☐ deep-well stream ___ of ___
- ☐ storage stream ___ of ___
- ☐ land application stream ___ of ___
- ☐ land application stream ___ of ___
- ☐ evaporation stream ___ of ___
- ☐ stream to municipal sewer ___ of ___
- ☐ other _____

contaminant	imposed limit		interpretational comments
	mg/l	kg/d	
ammonia nitrogen (NH_3-N) (as N)			
nitrate nitrogen (NO^-_3-N) (as N)			
total organic nitrogen (org N)			
phosphate (PO_4^{3-}) (as P_2O_5)			
total phosphorous			
fluoride (F^-)			
nickel (Ni)			
iron (Fe)			
copper (Cu)			
cobalt (Co)			
cyanide (CN^-)			
chromium (VI) (Cr^{6+})			
total suspended solids (TSS)			
biochemical oxygen demand (BOD)			
pH			
total organic carbon (TOC)			
uranium (U238)			
total α-particles			
total β-particles			
oil & grease			
toxicity test(specify):			
instream biological testing (specify):			
other:			
other:			
other:			
other:			

7. Phosphogypsum production

a) general

Has your facility ever produced any phosphogypsum? ☐ YES ☐ NO
Does your facility currently produce any phosphogypsum? ☐ YES ☐ NO

If you answered YES to either of these questions, please complete the remainder of this section:

➜ phosphogypsum... ☐ has been produced here since _____
☐ used to be produced here from _____ until _____

➜ products during whose manufacture phosphogypsum is (was) produced, and name of process that is (was) employed :

_____
_____
_____

➜ typical daily phosphogypsum production:
- _____ kg/day
- for year 19 ___

➜ cumulative phosphogypsum production to date:
- total mass: _____ kg
- total volume: _____ m^3

➜ how is (was) this phosphogypsum disposed of?
☐ phosphogypsum stacks
☐ added to or blended with other products
☐ recycled or re-used off site: _____
_____
_____
☐ other: _____
_____
_____

➜ if your facility has any phosphogypsum stacks (either active or decommissioned), please describe their physical characteristics:

- total number of stacks: _____
- source of phosphate rock: _____

	phosphogypsum stack number:					
	1	2	3	4	5	6
volume (m^3)						
area (m^2)						
active? (✔)						
inactive? (✔)						
being reclaimed (✔)						
reclaimed (✔)						
years of operation						

b) chemical properties

➜ if known, please describe the impurities that are present in each phosphogypsum stack (whether active or decommiissioned):

i) solid constituents

		phosphogypsum stack number:					
		1	2	3	4	5	6
mean DRY concentrations of phosphogypsum constituents (µg/g)	Cd						
	Se						
	Cr						
	Ag						
	F						
	U						
mean activity concentrations of dry phosphogypsum constituents (Bq/kg)	^{226}Ra						
	^{210}Pb						
	^{228}Th						
	^{210}Po						
	other						

ii) aqueous constituents, in phosphogypsum process water

		phosphogypsum stack number:					
		1	2	3	4	5	6
concentrations (mg/litre)	Cd						
	Cr						
	Pb						
	U						
	F^-						
radionuclide activities (Bq/litre)	^{226}Ra						
	^{210}Pb						
	^{228}Th						
	^{210}Po						
	other						

iii) other

	phosphogypsum stack number:					
	1	2	3	4	5	6
radon exhalation rate ($Bq/m^3 \cdot s$)						

c) reclamation

If any inactive phosphogypsum stacks have now been reclaimed or are currently in the process of being reclaimed, please describe briefly the reclamation measures that have been applied, when these measures were initiated, and the effectiveness of these measures thus far.

8. comments

Any comments which you would like to make concerning these limits, future trends in legislation in your local jurisdiction, or the industry in general would be greatly appreciated:

THIS IS THE END OF THE SURVEY
THANK YOU VERY MUCH!
YOUR COOPERATION IS GREATLY APPRECIATED!

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